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QUALITY FRUIT GROUP
MATURITY PROGRAMME

Annual Monitoring of the Maturity and Quality of UK apples and pears

REPORT 1999/2000

C T Biddlecombe
FAST Ltd

Dr M Luton
Qualytech

Quality Fruit Group Report 1999/2000

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UK APPLE AND PEAR MATURITY PROGRAMME 1999/2000

1 INTRODUCTION

English Apples and Pears Ltd formed the Quality Fruit Group in the Spring of 1994 to provide the UK Fruit Industry with detailed technical information on growing, harvesting and storage methods designed to ensure optimum texture and flavour in Cox apples and Conference pears at point of sale. The main work of the group was to set up a UK fruit maturity programme to give growers clear guidelines on optimum harvest dates for long term storage each season and to provide data to improve the understanding of our knowledge on the effects of fruit maturity at harvest on fruit quality of Cox after 4 and 7 months storage in ultra low oxygen.

The rate of deterioration of apples and pears in storage is influenced by their maturity at harvest. Research work at East Malling has shown a close relationship between the respiratory activity of Cox apples at harvest and the loss of eating quality in store and the susceptibility of fruit to low temperature injury, senescent breakdown and core flush. The harvest date, which was associated with the longest storage life and lowest incidence of storage disorders, occurred just prior to the onset of the respiration climacteric (Figure 1).

The onset of ripening is associated with the conversion of starch into sugar. Work carried out using taste panelists has consistently shown that, if fruit is picked before the starch has started to clear, the fruit coming out of store lacks flavour. As starch clears then the flavour potential increases, however the storage potential will tend to decrease. Thus a compromise has to be made between flavour and storage potential. In general, growers who have Controlled Atmosphere (C.A.) storage facilities of an average standard should start to pick their Cox apples when the starch pattern has fallen to 80% of the maximum coverage. They should aim to complete picking for long-term storage by the time the starch coverage has fallen to 70%.

In a study funded by the APRC the harvest and storage data from the first two years of the QFG maturity programme were used to produce a mathematical model for growers to predict fruit quality after 4 and 7 months storage in 1.2% oxygen at harvest.

Initially all the pre-harvest measurements of background colour, soluble solids, acidity, starch patterns and fruit firmness were included. The most significant of these attributes was fruit firmness. Including the other factors only marginally improved the accuracy of the model. Thus if fruit was picked at the correct firmness, it would have the right background colour, acidity and soluble solids after 4 or 7 months storage.

A simple model was produced that relates harvest firmness to ex-store firmness. (Table 1).

TABLE 1: Relationship between harvest and ex-store fruit firmness

Ex-store Firmness	Harvest Firmness (Kg)	
	January	April
6.5	9.4	10.2
6.0	8.2	8.7

By using the model and carrying out maturity assessments in individual orchards, growers could calculate the optimum harvest date for each orchard depending on the proposed storage period.

A number of other fruit qualities have to be considered when deciding when to pick commercially for long term storage. Cox fruits should have a light green background colour, at least 15% red colour, a fruit firmness of at least 8.6kg (11mm probe) and be 65-70mm in diameter. If harvest has to be delayed to improve fruit size or red colour then the length of the storage period has to be adjusted.

It has long been recognized that the best eating quality on Conference pears is associated with low starch content and high soluble solids when harvested. The recommended storage temperature for the variety is between -0.5°C and -1.0°C, thus it is important that fruit has an average soluble solids above 12% at harvest to avoid freezing in store.

The starch iodine test has been used for many years to indicate the finish date for harvesting pears for long term storage ie when the average starch pattern has decreased to one-third of the maximum average. Work carried out by ADAS and HRI East Malling indicated a more reliable guide to the cut off date for harvest could be obtained by including fruit firmness, soluble solids and starch pattern in a Streif index. Results from the first three years of the QFG maturity programme confirmed that the optimum harvest date for the long term storage of Conference pears coincided with a Streif index of 0.7.

Initially the project involved taking samples of Cox apples from 32 orchards and Conference pears from 12 orchards twice a week and measuring fruit size, colour, firmness, sugar content, acidity and starch pattern. On four separate occasions samples were taken and stored for 16 and 28 weeks after which time fruit was assessed for background colour, firmness and internal condition. The severe frost in April and May 1997 meant the UK crop for both Cox and Conference was very much reduced and the number of sites was reduced to 12 Cox and 5 Conference, for both that and the 1998 season.

The UK Apple and Pear Maturity Programme was set up with the following objectives.

1. To give clear guidance to the industry on the optimum picking periods for the major varieties.

2. To alert the industry to any quality problems in good time so that remedial action could be taken.

3. To assess the difference in maturity between the major growing areas of the country.

4. To provide a data base of pre and post harvest maturity attributes from a range of orchards over a number of seasons to improve the prediction in orchard to orchard and season to season variation on fruit maturity and storage potential.

The following report summarises the 1999/2000 programme.

2 MATERIALS

The eleven Cox orchards located in Kent, Essex, Suffolk and Norfolk used last season were sampled twice weekly in 1999 and storage samples were taken on four occasions. In a separate study staff from FAST carried out measurements in 3 orchards in the West Midlands and made the data available to the group.

Due to reduced funding the five Conference orchards used last season were reduced to three, one orchard was selected to represent each of the main growing areas, East Kent, West Kent, and East Anglia. Samples were taken twice weekly and storage samples were taken on four occasions.

Four Gala orchards located in Kent and Norfolk were again sampled in 1999. However unlike in previous seasons, storage samples were taken on three occasions and stored in two different Controlled Atmosphere storage regimes.

At each marker site, 20 representative trees were labeled along a single row adjacent to the rows used in the previous five years. This was done to eliminate any influence on cropping and fruit quality of the previous five years sampling and the effect of fruit being left on the tree after the optimum date. Trees were selected to have at least 100 fruit. Where this was not possible the number of trees labeled was doubled to 40 to provide sufficient fruit for the study including 4 x 30lbs of fruit for storage samples.

The trees were sampled on the 19/8, 23/8, 26/8, 31/8, 2/9, 9/9, 16/9, 23/9 and 30/9. The start date was anticipated as being three weeks before the optimum harvest window and the final sample a week after.

On each sampling occasion, two fruits were taken at random from within the cropping canopy of each tree making a total of 40 fruits per sample. In the case of trees carrying less than 100 fruits one apple was taken from each of 40 trees to give a similar sample size. Fruits were taken in such a way as to represent all positional aspects of the tree.

On four occasions at 7 days intervals starting on 2 September, a further 30lbs of fruit was harvested from 5 (10) pre-labelled trees in the row by picking 6lb (3lb) of fruit from a complete segment of the tree. Once harvested, these trees were discounted from the study.

3 METHODS

(i) Maturity Assessments

Size

On arrival at Brogdale (within 4 hours of harvest) the 40 fruits in each sample were examined visually and the five largest and five smallest fruits were discarded. The remaining 30 apples and pears were weighed and the average fruit diameter calculated by measuring the total length of the 30 fruits arranged in a line, and dividing the resulting measurement in mm by 30. After being weighed and measured 10 pear fruits were taken at random and discarded to leave a total sample size of 20 fruits.

Acidity

Ten apples were taken at random from the 30 fruits and used to measure acidity. Opposite eights were cut and the stalk and pips removed. The fruit was homogenised in a blender and 10mls of the juice removed and titrated against N $Na(OH)_2$ to an end point of pH 7. The results were expressed as mg of malic acid per 100 gram of fruit.

The remaining 20 apples and pears were arranged on a fibre cell liner and the first 10 fruits numbered 1-10 using a fibre pen. These fruits were assessed individually for colour, firmness, soluble solids and starch pattern, and the record kept separately allowing an index to be calculated for each apple.

Background Colour

Overall background colour was assessed visually for each of the ten Cox fruits using the Fruition colour card which divides background colour into green (1), light green (2), light yellow (3) and yellow (4).

Soluble Solids

A sample of juice was taken from each numbered apple or pear using a plastic probe, and placed in a hand held refractometer with a scale of 0-20%. The % soluble solid present in each fruit was recorded. At the start and end of each days reading the instrument was calibrated using a set of standard sugar solution (8, 10, 12 and 14%w/v). The individual fruit readings were adjusted using this calibration curve.

Fruit Firmness

A thin slice of peel was removed from opposite sides of the 10 numbered fruits and the firmness measured using an Effigi penetrometer mounted in a drill stand and fitted with an 11mm plunger for apples and an 8mm probe for pears. The results were expressed as average kg force for each fruit.

Starch

Each of the 20 fruits were then cut transversely through the equator and the cut surface dipped in a solution of 1% iodine and 4% potassium iodide. After 10 minutes the percentage area stained black was measured using a transparent sheet printed with a series of gauges ranging in diameter from 45-70mm, each gauge had printed on it a series of concentric rings representing 90%-50% starch pattern.

(ii) C.A. Storage (Cox)

On 2, 9, 16 and 23 September a 30lb box of fruit was harvested from 5 of the pre-labeled Cox trees as already described. Using this fruit four x 20 fruit netted storage samples were made up. The samples were transported and placed in a commercial controlled atmosphere store at <1%CO_2, 1.2%O_2 3.5°C. On each occasion the fruit was initially placed in a cold-store for 7 days to ensure it was thoroughly cooled. The four samples from each site were then placed in two empty bins, which had previously been left under the hatch of a 100 ton commercial store. Two nets from each site and each pick were placed in each bin to facilitate removal of samples in January and March.

On 19 January, two nets from each orchard and each harvest date were removed to assess fruit quality. One twenty fruit sample was used to carry out initial measurement of background colour, soluble solids and fruit firmness as previously described. The fruit was then assessed externally for any sign of fungal infection before being cut and the internal condition of the fruit recorded.

The second netted samples were placed at 18°C for 7 days before being assessed for internal and external condition.

On 28 February the remaining two nets from each orchard and harvest date were removed from store and assessed as before.

(iii) Air Storage -1°C (Conference)

Thirty pounds of Conference pears were picked on the 2nd, 9th, 16th and 23rd of September and transported to a commercial pear store in West Kent the same day where they were stored in air at -0.5 to -1.0°C.

Twenty five fruits were removed from each sample on the 24th January and placed in a ripening room at 18°C for 10 days. Penetrometer measurements (8mm probe) were made on opposite sides of 5 fruits after 0, 1, 2.5 and 4 days at 18°C. The samples were then cut longitudinally and examined for the presence of physiological disorders and storage rots. The remaining 10 fruits were examined for physiological disorders and rots after 10 days at 18°C.

On the 5th May the remaining fruit was removed from store, the total number of pears and those showing signs of fungal spoilage were counted. Twenty five sound pears from each

sample were taken and placed in a ripening room at 18^0 C for ten days. Soluble solids were measured on ten fruits before fruit firmness was measured on opposite sides of five of then. Penetrometer measurements were again made on opposite sides of five fruits after 3 days at 18^0C. The remaining 10 fruits were examined for physiological disorders and rots after 10 days at 18°C.

(iv) C.A. Storage Gala

On 16, 23 and 30 of September two 30lb boxes of fruit were harvested from 5 pre-labelled Gala trees as already described. Using this fruit eight x 20 fruit netted storage samples were made up. The samples were placed in two small eight ton controlled atmosphere store at Brogdale that had already been filled with the same variety. One store was held at 8% CO_2 1.0^0C while the other was run at 5%CO_2, 1.0%O_2 1.0°C. On each occasion the netted fruit samples were initially placed in a cold store for 7 days to ensure they were thoroughly cooled. Four nets from each site were then placed in a part filled bulk bin which had previously been left under the hatch of each store.

On 13 December, two nets from each orchard and each harvest date were removed from each store to assess fruit quality. One twenty fruit sample was used to carry out initial measurement of background colour, soluble solids and fruit firmness as previously described. The fruit was then assessed externally for any sign of fungal infection before being cut and the internal condition of the fruit recorded.

The second netted samples were placed at 18°C for 7 days before the fruit was again assessed for background colour, fruit firmness and internal condition.

On 21 February the remaining two nets from each orchard and harvest date were removed from each store and assessed as before.

4 RESULTS

(i) Harvest

The average fruit weight, diameter, background colour, soluble solids, acidity, firmness and starch pattern was calculated for each orchard on each sample date.

For each of the 10 individual fruits in the sample a maturity index was calculated as follows. The % starch was converted into a 1-10 scale using a conversion table (Table 2).

TABLE 2: Relationship between % starch pattern and 1-10 scale.

% STARCH (Black)	1-10 SCALE	% RANGE
100	1	100
80	2	77.6 - 99.9
75	3	70.1 - 77.5
65	4	57.6 - 70.0
50	5	40.1 - 57.5
30	6	27.6 - 40.0
25	7	17.6 - 27.5
10	8	7.6 - 17.5
5	9	2.6 - 7.5
0	10	0 - 2.5

Using the following formula the index for each of the 10 individual numbered apples and pears in the sample was calculated.

$$\frac{\text{Firmness (kg)} \times 9.81}{\text{Soluble solids (\%)} \times \text{starch pattern (1-10)}}$$

The mean maturity index for each orchard at each sampling date was found by taking the average of the 10 individual fruits.

(a) Cox

The sample date where average fruit diameter at each site first reached 65mm was noted (Table 3).

TABLE 3: Date at which average fruit at each Cox site reached 65mm diameter, a starch pattern of 70%, a firmness value of 8.6 or 8.0 kg (11mm probe) and an index of 2.1 in 1999.

ORCHARD DETAILS			CALENDAR DATE				
Area	**Site Code**	**Root stock**	**65mm diam**	**70% Starch**	**8.6kg Firm**	**8.0kg Firm**	**2.1 Streif Index**
Kent (K)	K1	MM106	23/08	24/08	03/09	10/09	26/08
	K3	MM106	23/08	27/08	11/09	16/09	27/08
	K7	M9	23/08	07/09	16/09	23/09	10/09
	K10	MM106	26/08	31/08	15/09	23/09	03/09
	K11	M9	26/08	05/09	15/09	23/09	10/09
	K12	M9	23/08	02/09	09/09	16/09	02/09
	K13	M9	23/08	01/09	04/09	11/09	02/09
Essex (E)	E4	M9	19/08	30/08	08/09	18/09	31/08
Suffolk (SF)	SF2	M9	26/08	31/08	12/09	19/09	02/09
	SF5	M9	31/08	02/09	14/09	23/09	31/08
Norfolk (N)	N3	M9	23/08	29/08	05/09	13/09	29/08
West Midlands (WM)	WM4	MM106	09/09	19/09	26/09	N/A	23/09
	WM5	M9	02/09	14/09	18/09	26/09	14/09
	WM7	MM106	02/09	19/09	16/09	26/09	21/09

Graphs were plotted of fruit firmness, starch pattern and maturity index with time using the data collected from mid-August until late September at each site (Appendix 1). A linear regression was fitted to both the fruit firmness and starch pattern data. The date at which the average fruit firmness fell to 8.6kg or 8.0kg and the starch pattern declined to 70% was calculated from these regressions. A curve was fitted to the maturity index data and the date the index reached 2.1 extrapolated (Table 3).

(b) Conference

The sample date where average fruit diameter at each of the three orchards first reached 55mm was noted (Table 4).

For each of the 3 pear orchards graphs of change in fruit firmness, starch pattern and maturity index with time were plotted (Appendix 2). From these graphs the date the starch pattern reached 2/3 maximum and 1/3 maximum was extrapolated together with the date the maturity index reached 1.0 or 0.7 and fruit firmness fell to 6kg (Table 4).

TABLE 4: Date at which average fruit at each Conference site reached a diameter of 55mm, two thirds and one third of maximum starch pattern, a maturity index of 1.0 or 0.7 and a firmness of 6.0kg in 1998.

Area	Orchard Ref No:	Diameter 55mm	Starch 2/3	Starch 1/3	Index 1.0	Index 0.7	Firmness 6.0kg
Kent (KP)	KP1	23/08	09/09	16/09	09/09	17/09	15/09
	KP6	23/08	31/08	20/09	09/09	16/09	08/09
East-Anglia (EAP)	EAP2	26/08	22/08	29/08	25/08	31/08	02/09

(c) Gala

The sample date at which fruit from each site reached a mean diameter of 65mm was noted, Table 5.

As for the Cox sites, graphs were plotted of fruit firmness, background colour, soluble solids, starch pattern and maturity index with time using the data collected from mid-August until late September at each site (Appendix 3). A linear regression was fitted to both the fruit firmness and starch pattern data. The date at which the average fruit firmness fell to 8.6kg and the starch pattern declined to 90, 70, or 50% was calculated from the regression lines. A curve was fitted to the maturity index data and the date the index reached 2.1 extrapolated for each site (Table 5).

TABLE 5: Date at which average fruit at each Gala site reached a diameter of 65mm, starch pattern 50, 70, 90%, fruit firmness 8.6kg and index 2.1.

Site Code	Size 65mm	Starch			Firmness 8.6kg	Streif 2.1
		90	70	50		
GALA1	09/09	30/08	13/09	21/09	25/09	17/09
GALA2	31/08	06/09	14/09	21/09	22/09	18/09
GALA3	02/09	02/09	17/09	21/09	N/A	22/09
GALA4	19/08	31/08	10/09	14/09	23/09	14/09

(ii) Storage

(a) Cox

The average fruit firmness, sugar content and background colour of ten fruits was calculated for each orchard at each pick after 18 weeks in Controlled Atmosphere storage. The number of fruit in each sample with fungal infection or internal storage disorders was noted. After 7 days at 18°C the number of apples in each sample showing fungal infection and internal storage disorders were noted (Appendix 4).

The average fruit firmness, sugar content and background colour of ten fruits was again calculated for each orchard at each pick after 24 weeks in Control Atmosphere storage. After 7 days shelf life at 18°C the number of apples in each sample showing fungal infection and internal storage disorders were noted (Appendix 5).

(b) Conference Storage

The average fruit firmness of five fruits was calculated for each orchard at each pick after 18 weeks in air storage at –1.0°C after 0, 1, 2.5 and 4 days at 18°C was calculated. (Appendix 6).

The average fruit firmness of five fruits was calculated again for each orchard at each pick after 28 weeks in air storage at –1.0° C after 0 and 3 days at 18°C. The % fruit with internal breakdown or showing fungal infection after 10 days at 18°C was calculated. (Appendix 6).

(c) Gala Storage

The average fruit firmness, sugar content and background colour of ten fruits was calculated for each orchard at each pick after 14 weeks in either 8% CO_2 1.0°C or 5%CO_2 1%O_2 1.5°C. The number of fruit in each sample with fungal infection or internal storage disorders was noted. After 7 days at 18°C the average fruit firmness and background colour of ten apples from each sample was calculated and the number of apples showing fungal infection and internal storage disorders were noted (Appendix 7).

The average fruit firmness, sugar content and background colour of ten fruits was again calculated for each orchard at each pick after 22 weeks in control Atmosphere storage (8%CO_2 or 5%CO_2 1%O_2). After 7 days shelf life at 18°C the number of apples in each sample showing fungal infection and internal storage disorders were noted (Appendix 8).

5 DISCUSSION

(i) Cox Harvest

(a) Fruit Size

As in the previous five seasons fruit size increased by about 2.5mm a week during August. At the beginning of September fruit growth appeared to stop for a short period. It then increased at 2.0mm a week between the 2nd and 9th September, before slowing down and stopping again on the 16th (Figure 2). In general fruit size was 4-5mm larger than that recorded in 1994, 95 and 96, 2mm larger than 1998 and similar to that found in 1997.

Overall fruit size reached 65mm on the 27th August. This was the earliest date in the six years of the study and four days earlier than that recorded in 1997 (Table 6). The Kent sites reached an average of 65mm on the 24th August, this was one day earlier than the East Anglian sites and 11 days before those in the West Midlands.

TABLE 6: Date on which mean fruit size reached 65mm at the average site in 1994, 95, 96, 97, 98, 99 and for the average sites in Kent, East Anglia and the West Midland area.

CALENDER DATE FRUIT SIZE REACHED 65MM				
Year	**All Sites**	**Kent Sites**	**East Anglian Sites**	**West Midland Sites**
1994	13/09	10/09	16/09	29/09
1995	06/09	31/08	12/09	N/A
1996	15/09	11/09	20/09	03/09
1997	31/08	29/08	05/09	31/08
1998	04/09	03/09	04/09	08/09
1999	27/08	24/08	25/08	04/09

(b) Background colour

In 1999 average fruit background colour was very similar to that recorded in 1998 and slightly paler than that measured in 94,95,96 and 1997 (Figure 3). Background colour started mellowing rapidly (0.5 units a week) on the 2nd September and reached an average of 2 by the 9th of the month. This was two days earlier than last season and about three weeks sooner than the other years in the study.

(c) Soluble solids

Soluble solids were very similar to that recorded in, 1994, 96 and 97 and about 1-1.5% lower than that recorded in 1995 and 1998. Initially the rate of increase was very slow and at 0.06% a day (0.5% week) about half that recorded in the previous five seasons

(Figure 4). However from the 9th September until the end of the study, the rate almost doubled to 0.11% a day (0.8% week). This was a similar rate to that recorded in the previous five seasons.

(d) Acidity

Initially, at 10.6mg $100g^{-1}$, the acidity of fruit was very low, 0.5 to 1.5mg below that recorded in the previous five seasons (Figure 5). However between the 26th and 31st August the concentration increased by 0.4mg and although still the lowest recorded for the six years was similar to that found in 1994. Overall the rate of decline in acidity at 0.6mg a week was similar to previous years.

(e) Fruit Firmness

The way in which fruit firmness altered with time was very similar to that recorded the previous year (Figure 6). Initially at 10.1 kg the level was the same as that recorded in 1998, and about 1.0 to 1.5 kg lower than that recorded in 1994, 95 and 96. The rate of decline during August at 0.04kg a day was the lowest recorded and under half the standard rate of 0.1kg a day. After the 2nd September the rate doubled to 0.09kg a day which was close to the rate recorded in previous seasons.

Overall the average fruit firmness reached 8.6kg on the 12th September, Table 7. This was two days later than last season, five days earlier than 1994, 95, almost two weeks earlier than 1996 and nine days later than the earliest season in the study of 1997. Both the Kent and East Anglian sites reached an average of 8.6kg on the 10th September, for the latter this was three days sooner than the previous year. The West Midland sites were ten days later than both the other sites and there average for the previous season.

TABLE 7: Date on which the mean fruit firmness reached 8.6kg at the average site in 1994, 95, 96, 97, 98, 99 and for the average sites, in Kent, East Anglia and the West Midlands area.

CALENDER DATE FRUIT FIRMNESS REACHED 8.6Kg				
Year	**All Sites**	**Kent Sites**	**East Anglian Sites**	**West Midland Sites**
1994	17/09	16/09	17/09	>03/10
1995	17/09	16/09	17/09	>28/09
1996	25/09	22/09	25/09	>07/10
1997	03/09	30/08	08/09	>24/09
1998	10/09	09/09	13/09	10/09
1999	12/09	10/09	10/09	20/09

(f) Starch Pattern

The overall decline in starch pattern at about 2.5% a day was very similar to the rate recorded in the previous five years. However as in 1997 and 98 the decline started much

earlier on the 19th August, compared to 1995 and 96 where starch patterns did not start to change until the first week of September, Figure 7. The very large fall in the starch pattern, 92% down to 77%, in three days between 23rd and 26th August, has not been recorded in any other year in the study and at 5% per day represents a fall of double the expected rate 5% a day.

Due to the rapid decline in starch pattern at the end of August the average fruit starch pattern reached 70% on the 4th September, the earliest recorded in the six years of the study. This was two days earlier than the previous season and two weeks earlier than the latest season of 1996. (Table 8)

The average East Anglian sites were one day earlier than the Kent sites, where as the West Midland sites were 16 days later.

TABLE 8: Date on which mean fruit starch pattern fell to 70% at the average site in 1994, 95, 96, 97, 98, 99 and for the average sites in Kent, East Anglia and the West Midlands area.

CALENDER DATE AVERAGE STARCH PATTERN 70%				
Year	**All Sites**	**Kent Sites**	**East Anglian Sites**	**West Midland Sites**
1994	09/09	04/09	08/09	29/09
1995	14/09	13/09	12/09	N/A
1996	18/09	16/09	17/09	29/09
1997	07/09	31/08	04/09	16/08
1998	06/09	03/09	06/09	17/09
1999	04/09	01/09	31/08	17/09

(g) Maturity Index

As in previous seasons the maturity index did not show as large a variation between the sites as either the fruit firmness or starch pattern alone. This is due to the combination of three variables having a 'smoothing out' effect on the data.

Initially the index fell rapidly at 0.5 units a day, this was similar to the previous two seasons and almost double the rates recorded in 1994, 95 and 96, Figure 8. As in previous seasons the index flattened out at about 2.0.

On average the index reached 2.1 on the 5th September, this was one day earlier that last season, three days earlier that 1997, about a week earlier than 1994, 95 and two weeks sooner than 1996 (Table 9).

The East Anglian sites reached an index of 2.1 on 31st August, this was over a week earlier than last season, three days before the Kent sites and almost three weeks sooner than the West Midland sites.

TABLE 9: Date on which mean fruit index reached 2.1 at the average site in 1994, 95, 96, 97, 98, 99 and for the average sites in Kent, East Anglia and the West Midlands area.

CALENDAR DATE AVERAGE INDEX REACHED 2.1				
Year	**All sites**	**Kent Sites**	**East Anglia Sites**	**West-Midland Sites**
1994	09/09	04/09	08/09	29/09
1995	14/09	13/09	12/09	N/A
1996	18/09	16/09	17/09	29/09
1997	07/09	31/08	04/09	16/09
1998	06/09	03/09	06/09	17/09
1999	04/09	01/09	31/08	17/09

(ii) Conference Harvest

(a) Fruit size

During the first week of the study fruit size increased rapidly by 0.65mm a day. This was twice as fast as the rate previously recorded and the average fruit size rose from 52.4mm on the 19th August to 57mm by the 26th. Subsequently the rate fell to 0.33mm a day, 2.5mm a week, this was similar to the previous five years of the study. Growth continued at this rate until the 9th of September after which time it appeared to stop, having reached a maximum of 58mm (Figure 9).

(b) Soluble solids

Soluble solids increased by about 0.1% a day during August, this was similar to the rate found in the previous five years. During the first two weeks of September there appeared to be no increase in the average sugar content of the fruit, which remained at about 14%. However in the last week of the study the level rose by 1.5% finishing at 15.5% on the 23rd of September (Figure 10).

(c) Fruit Firmness

Fruit firmness fell at a steady rate during the entire period of the study, 0.07kg a day, 0.5kg a week. This was the same as found in the previous five seasons, (Figure 11).

(d) Starch Pattern

The maximum average starch pattern recorded in 1999 was 73% on the 19th August. Starch pattern declined very rapidly, 3.3% a day, in the first week. The average pattern fell from a maximum of 73% to 49%, two thirds by 26th August. Following this, the pattern declined very slowly, 0.62% a day for the next three weeks. After the 16th

September the rate increased to 2.6% a day, this was very close to the rate recorded in the previous five years for the variety (Figure 12).

(e) Index

The rapid decline in starch pattern produced a similar decline in the index during the first week of the study. The index fell by over 0.1 units a day, from 2.0 on the 19th to 1.2 by the 26th of August. After this the decline, at 0.02 units a day, was very much slower and it was not until the 16th of September that the value reached 0.7 (Figure 13).

Using data from the three Conference pear sites the date when the average fruit size reached 55mm diameter, firmness 6.0kg, starch pattern 2/3 and 1/3, and an index of 1.0 and 0.7 were calculated, Table 10, and compared with the previous five years.

TABLE 10: Date on which mean fruit size reached 55mm, firmness 6.0kg, starch pattern 2/3 and 1/3 of maximum and maturity index 1.0 and 0.7 at the average site in 1994, 95, 96, 97, 98, and 99.

Year	55mm Diam	Firm 6.0kg	2/3 Starch	1/3 Starch	Index 1.0	Index 0.7
1994	30/08	17/09	08/09	18/09	05/09	17/09
1995	30/08	14/09	12/09	16/09	12/09	14/09
1996	04/09	24/09	07/09	19/09	09/09	16/09
1997	07/09	13/09	09/09	22/09	14/09	19/09
1998	27/08	11/09	07/09	20/09	06/09	11/09
1999	24/08	08/09	01/09	11/09	05/09	11/09

(iii) Gala Harvest

A summary of the pre-harvest measurements of fruit size, background colour, soluble solids, firmness, starch pattern and index for 1999 are shown in figure 14. Each point is the mean of the four sites used in the study.

(a) Size

The average fruit size increased by 3mm a week during the last week of August and the first week of September. Size continued to increase slowly reaching a maximum of 68mm on the 17th of September. This was very similar to last year

The average fruit size reached 65mm on the 31st of August this was seven days earlier than last seasons date of 7th of September.

(b) Background colour

The average background colour changed very rapidly after the 26th of August reaching a index of 3.5 on the 9th of September. This was very similar to that recorded last season.

(c) Soluble Solids

The average sugar content rose by 0.1% a day from the middle of August until the middle of September reaching a maximum of 13.8% on the 23rd of September. This was almost identical to that recorded in 1998 and a similar maximum for that season of 13.7% on the 21st of September.

(d) Fruit firmness

Unlike Cox the average fruit firmness fell by 0.1kg a day during the entire period of the study and reached 8.6kg on the 25th of September. Once again this was a similar rate to that found in the previous season and at the 23rd of September a similar date to that found in 1998.

(e) Starch pattern

In contrast to Cox the starch pattern did not change very much in August, however on the 2nd of September the pattern broke and continued to fall by almost 3% a day. The starch pattern at the average site reached 90, 70 and 50% on the 2nd, 12th and 19th of September respectively. This was between three and five days earlier than last seasons dates for the corresponding starch pattern.

(f) Index

With the very small change in the mean starch pattern during August the maturity index which includes a starch value also had a very small rate of change, 1.0 unit a week. As the starch pattern declined rapidly in September, the rate in the decline of the index almost doubled to 1.8 units a week. The maturity index reached the value of 2.1 at the average site on the 18th of September. Despite the increase in the rate the index changed during September it was significantly lower than last seasons rate of almost 3 units a week. However the threshold of 2.1 was achieved on the same date in 1998.(Table 11)

TABLE 11: Date on which mean fruit size reached 65mm, firmness 8.6kg, 90, 70 and 50% starch pattern and a maturity index of 2.1 at the average site in 1998 and 99.

Year	Size 65mm	Firmness 8.6kg	Starch pattern			Index 2.1
			90	70	50	
1998	07/09	22/09	07/09	14/09	22/09	18/09
1999	31/08	19/09	02/09	12/09	19/09	18/09

(iv) Storage Cox

(a) January

A summary of the storage information obtained from the first inspection is shown in Table 12.

TABLE 12: Effect of harvest date on the storage quality of Cox's Orange Pippin apples stored in 1.2% O_2 (<1%CO_2) at 3.5°C until early January (18 weeks). Figures in brackets refer to fruit kept in air at 18°C for a further 10 days to simulate marketing.

Harvest Date	Firmness Kg	Sugar %	Colour 1-4	Rots %	Bitter Pit	Breakdown
02/09/99	7.8	14.3	1.6	2.5	2.0	2.0
09/09/99	7.1	14.0	1,7	3.0	1.5	1.5
16/09/99	6.9	14.2	2.0	2.5	0.5	2.0
23/09/00	6.1	14.1	2.6	5.5	0.5	0

Footnotes
1. Fruition colour card 1 = green 4 = yellow colour grade 2 optimum for marketing.
2. Firmness measured using an Effigi penetrometer fitted in a drill stand.

Each figure is the mean of the 14 Cox sites used in the study. After 18 weeks storage at <1%CO_2 1.2%O_2 3.5°C the average fruit firmness for fruit picked on the first three harvest dates was above the threshold of 6.5kg required ex-store to ensure sufficient shelf life to reach the standard for most retail outlets. Of the 14 sites in the study all had average fruit firmness above 6.5kg after 18 weeks storage when picked on the 2nd September. Two of the 14 sites failed to make the 6.5kg threshold when picked on the 9th September, this doubled to four sites a week later. By the 23rd September only the three West Midland sites came out of store in mid-January with penetrometer readings above 6.5kg.

Figure 15 shows the relationship between fruit firmness at harvest and after 18 weeks storage in 1.2%O_2 3.5°C for samples of fruit from each of the 14 sites for the four different harvest dates. To ensure that fruit from all the sites came out of the store with a firmness above 6.5kg then the harvest firmness needed to be above 9.1kg. If the ex-store firmness threshold were to be reduced to 6.0kg then the fruit had to be harvested with a firmness of at least 8.6kg.

This is very similar to the values of 9.4 and 8.2kg predicted by Martin Ridout's model produced using the first two years data from the 32 sites originally involved in the study.

Last season, using fruit from basically the same sites the thresholds at 8.3 and 7.6 kg were respectively 0.8 and 1.0kg lower than either those of the original model or this seasons values.

Background colour mellowed very slowly with delayed harvest and only fruit picked on the last harvest date had an average value above the required standard of 2.

In general all sites had fruit with a background colour of two or below when harvested on or before 16th September and stored in ultra low oxygen for 18 weeks. When picked a week later on the 23rd September all but one of the sites had background colours above index 2 after 18 weeks storage.

The average sugar content of fruit after 18 weeks storage was 14.3, 14.0, 14.2 and 14.1 for each of the respective harvest dates. This compared with averages of 11.7, 12.2, 13.0 and 13.7 at harvest. Thus regardless of sugar content measured at harvest using a refractometer the value after 18 weeks storage was similar at about 14%.

Fungal wastage was between 2.5 and 5.5% initially. Delaying the harvest until 23rd September doubled the level of rots found immediately ex-store. A trace of bitter-pit was found immediately ex-store this increased significantly after 10 days shelf life. The level of bitter-pit decreased with delayed harvest and was found in only three of the 14 sites. A small amount of breakdown, mainly related to water core was found but again this was confined to the three sites where bitter-pit had been found. Like bitter-pit the level decreased with delayed harvest, and reflected the fact that the breakdown was associated with water core.

(b) March

TABLE 13: Summary of results from the second inspection of fruit stored for 24 weeks in <1.2%O_2 1%CO_2 at 3.5°C until March. Figures in brackets refer to fruit kept in air at 18°C for a further 7 days to simulate marketing.

Harvest Date	Firmness Kg	Sugar %	Colour 1-4	Rots %	Bitter Pit	Breakdown
02/09/99	7.1	13.8	1.7	3.5 (4.5)	6.5 (11.4)	1.5 (2.3)
09/09/99	6.5	13.6	1,9	5.5 (8.2	5.5 (5.4)	0.5 (5.0)
16/09/99	6.2	14.0	2.0	4.5 (8.2)	1.5 (6.8)	2.5 (6.1)
23/09/00	5.7	13.8	2.4	7.0 (16.9)	0 (1.9)	2..0 (4.2)

Footnotes

1. Fruition colour card 1 = Green 4 = yellow, colour grade 2 optimum for marketing.
2. Firmness measured using an Effigi penetrometer fitted in a drill stand.

The average fruit firmness for the first three harvest dates has fallen by 0.7kg compared to the averages found in January. The average firmness for fruit picked on the 23rd September, after 24 weeks storage at 5.7kg is 0.4kg lower than that recorded six weeks earlier in mid-January. The average fruit firmness for fruit picked on the 2nd and 9th September and stored for 4 weeks in <1%CO_2 1.2%O_2 3.5°C was above the threshold of 6.5kg required ex-store to ensure sufficient shelf life to meet the requirements of most retail outlets.

Of the 14 sites in the study only one had an average fruit firmness below 6.5kg when picked on the 2nd September. When picked on the 9th September four sites failed to meet the 6.5kg this rose to 11 sites by the 16th September. No site achieved the 6.5kg threshold when picked on the 23rd September and stored for 24 weeks in ultra low oxygen.

Figure 16 shows the relationship between fruit firmness at harvest and after 24 weeks in CA storage at <1%CO_2 1.2%O_2 3.5°C, using data from each of the 14 sites and four different harvest dates.

To ensure that fruit from each of the sites came out of store with a firmness of 6.5kg or above after 24 weeks storage in ultra low oxygen then the harvest firmness in 1999 needed to be at least 9.6kg. If the ex-store firmness was reduced to 6.0kg then fruit needed to be picked with a firmness above 8.9kg.

These figures are very similar to those predicted by Martin Ridout's model of 10.2 and 8.7kg produced using data from the first two years of the study, and over 1.0kg higher than last years requirements of 8.4 and 7.8kg.

The average background colour did not change compared to that recorded in mid-January. Once again background colour was found to mellow slightly with delayed picking, however, the average index for the first three harvest dates were 2.0 or below. Even fruit picked on the last date, only just had an index above 2.0. This is in contrast to last season when fruit from the last two harvest dates had a definite yellow appearance after 28 weeks storage.

Fruit from all 14 sites picked on the 2nd September had background colours below value 2. Harvested a week later three of the 14 sites had background colours just over 2, after 24 weeks storage in <1%CO_2 1.2%O_2 3.5°C. By the third harvest on the 16th September over half, ten sites, had average values above 2. Only one site, 4, had a background colour below 2 when harvested on the 23rd September and stored for 24 weeks in ultra low oxygen.

Sugar levels in all the samples after 24 weeks storage were 0.2 to 0.5% lower than the corresponding figure obtained in mid-January. There was once again no significant effect of harvest date on sugar content and all the averages were between 13.6 and 14%.

The level of rots found immediately ex-store after 24 weeks storage increased very slightly compared to that found in mid-January. The main rots found were Nectria and Penicillium. The total % losses due to rotting doubled between pick 1 (3.5%) and the final pick (7.0). The level of bitter-pit found increased after 24 weeks storage compared to that found after 18 weeks. Delaying the harvest reduced the average level of bitter-pit found immediately ex-store from 6.5% down to zero at pick 4. Once again the disorder was mainly found in samples from three sites.

The initial level of breakdown after 24 weeks was very similar to that found after 18 weeks and did not appear to increase with delayed harvest. A range of internal disorders

were found including, 'Boggy Bank', Late Storage Corking, Diffuse Breakdown and Senescent Breakdown. The occurrence of breakdown did not appear to be confined to individual sites or harvest date.

(v) Storage Conference Pears

The storage results for each of the three orchards in the study are presented in Annexe 5.

Generally there is little influence of pre-harvest factors on the storage quality of Conference pears. Correct harvest date combined with good storage practice should ensure satisfactory quality over the recommended duration of storage. Optimum harvest date is considered to be that which satisfies the following:

- A minimum ex-store firmness of 4.5kg to avoid damage during mechanical grading and marketing.
- Minimal rotting.
- Freedom from physiological disorders and senescent breakdown.
- Maximum eating quality.

(a) January

The average data for the three orchards after 18 weeks storage are presented in Table 14.

TABLE 14: The effect of harvest date on the storage quality of Conference pears stored in air at -1°C until early January (18 weeks). Each figure is the mean of three sites.

Harvest Date	02/09	09/09	16/09	23/09
Firmness Day 0 at 18°C	5.4	5.3	4.5	4.2
Days at 18°C to 1.5kg	4.8	4.6	5.1	4.6
% breakdown	0	0	0	0
% rots	0	1.5	1.5	3.0
% soluble solids at harvest	12.7	12.8	13.0	14.4

After 18 weeks storage in air at -1°C the average fruit firmness for the first three picks were above the 4.5kg recommended to avoid damage during grading. Fruit picked on the 23rd September had an initial fruit firmness of 4.2kg and thus failed to meet the 4.5kg threshold. All samples took on average between 4.6 and 5.1 days to reach eating ripe, 1.5kg. There appeared to be no effect of harvest on ripening rate and all samples were close to the standard five days. The concentration of soluble solids in fruit from all four harvest dates was sufficiently high to provide good eating quality. None of the fruits examined after 18 weeks storage showed any signs of internal breakdown. The level of rotting in all the samples was very low but increased with delayed harvest and doubled between the 16th and 23rd September.

Thus the picking dates that satisfied all the criteria listed above after 18 weeks storage in air at -1°C was between 2nd and 16th September.

(b) May

The average data for the three orchards after 32 weeks storage in air at -1°C are presented in Table 15 for each of the four harvest dates.

TABLE 15: The effect of harvest date on the storage quality of Conference pears stored in air at -1°C until May (32 weeks). Each figure is the mean of three sites.

Harvest date	02/09	09/09	16/09	23/09
Firmness day 0 at 18°C	4.1	3.9	3.7	3.5
Days at 18°C to 1.5kg	3.2	2.9	3.0	2.8
% breakdown	0	0	10	20
% rots	2.3	7.9	18.2	21.8
% soluble solids ex-store	14.1	14.1	14.5	14.5
% soluble solids at harvest	13.9	13.9	14.2	14.4

After 32 weeks storage in air at –1°C the average fruit firmness for all the sites was below the threshold of 4.5kg. Of the three sites two had average firmness values of 4.5kg for fruit picked on the 2nd of September. At both sites the value had fallen to 4.0kg by the second harvest date. The average maturity index on the 2nd of September was 1.0 this was 0.3 higher than the index of 0.7 previously found to be the minimum required for long term storage. The two sites where the average fruit firmness values were at 4.5kg, had indices of 1.15 and 1.26 when picked. Thus it would appear that the minimum maturity index in 1999 was higher than previously recorded. However in previous years fruit had only been stored until the beginning of April. All the sites showed a significant drop in fruit firmness between 18 and 32 weeks storage with the earlier harvested fruits showing a larger fall. All samples took between 2.8 and 3.2 days at 18°C to reach eating ripe, 1.5kg.

This was about two days faster than that recorded in January, however as previously found there appeared to be no effect of harvest date on ripening rate.

One site had a significant amount of internal breakdown in the fruit immediately ex-store when picked after the 9th of September. The level of rots increased significantly with delayed harvest.

Soluble solids at harvest ranged from 13.9 to 15.5, after 32 weeks storage all samples had concentrations just over 14% regardless of harvest date.

Thus the picking date to satisfy all the criteria listed above was before the 2nd of September for air storage until early May.

(vi) Gala storage

(a) December

A summary of the Gala storage data from the three different harvest dates after 14 weeks storage in either 8% CO_2 or 5% CO_2 1.2% O_2 at 1.0^{0}C are shown in table 16.

TABLE 16: Effect of harvest date and storage conditions on the quality of Gala apples stored in either 8% CO_2 1.0^{0}C or 5% CO_2 1.2% O_2 1.5^{0}C until the middle of December (14 weeks). Figures in brackets refer to fruit kept in air at 18^{0}C for a further 7 days to simulate marketing.

Storage Regime	Harvest Date	Firmness		Colour		Sugar %	Disorders %					
			+7d		+7d		Core flush		Senescent		Rot	
8% CO_2	16/09	8.1	7.1	4.3	4.6	14.8	0	(0)	0	(0)	0	(0)
	23/09	7.6	6.8	4.4	4.8	14.6	0	(0)	0	(0)	0	(0)
	30/09	7.6	6.6	4.6	4.9	14.7	0	(0)	0	(0)	0	(0)
5% CO_2 1.2% O_2	16/09	8.0	8.0	4.3	4.4	14.7	0	(0)	0	(0)	0	(0)
	23/09	8.1	7.9	4.4	4.6	14.9	0	(0)	0	(0)	0	(0)
	30/09	7.9	7.8	4.5	4.9	14.2	0	(0)	0	(0)	0	(0)

The effect of harvest date on fruit firmness either immediately ex-store or after 7 days shelf life is minimal for fruit stored in 5% CO_2 1.2% O_2 until mid December. Fruit stored in 8% CO_2 show a decline in fruit firmness both immediately ex-store or after seven days shelf life with delayed harvest. Fruit picked on the 30th of September being about 0.5kg lower than that picked two weeks earlier. The striking feature of the data is the effect of storage conditions on shelf life. Fruit from 5% CO_2 1.2%O_2 shows very little change in average firmness after seven days at 18^{0}C, where as samples stored in 8% CO_2 exhibit about a kilogramme fall in pressure over the same period.

There was very little effect of harvest date, storage conditions or shelf life on fruit background colour, sugar content or the occurrence of storage disorders. Despite not being treated with a post-harvest fungicide, no fungal spoilage was found. Although the average sugar content at harvest varied between the different picking dates there was no such difference after 14 weeks storage.

(b) Mid February

A summary of the Gala storage data for the three different harvest dates after 22 weeks storage in 8% CO_2 or 5% CO_2 1.2% O_2 are shown in table 17.

TABLE 17: Effect of harvest date and storage conditions on the quality of Gala apples stored in either 8% CO_2 1.0^{0}C or 5% CO_2 1.2% O_2 1.5^{0}C until the middle of February (22 weeks). Figures in brackets refer to fruit kept in air at 18^{0}C for a further 7 days to simulate marketing.

Storage Regime	Harvest Date	Firmness	+7d	Colour	+7d	Sugar %	Disorders % Core flush		Senescent		Rot	
8% CO_2	16/09	7.6	5.5	4.5	4.8	15.2	16	(28)	0	(15)	1	(5)
	23/09	7.2	5.3	5.0	4.9	15.4	20	(26)	0	(40)	3	(1)
	30/09	6.6	4.9	5.0	4.9	14.8	25	(40)	0	(66)	1	(2)
5% CO_2 1.2% O_2	16/09	8.1	7.7	4.8	4.6	15.6	0	(0)	0	(0)	0	(5)
	23/09	7.7	7.4	4.7	4.8	15.2	0	(0)	0	(1)	1	(3)
	30/09	7.6	7.0	4.9	4.8	14.7	0	(0)	0	(20)	1	(10)

There was very little change in fruit firmness for the sample stored in 5% CO_2 1.2% O_2 and picked on the 16th of September compared with the value obtained eight weeks earlier. Delaying the harvest of fruit stored in 5% CO_2 1.2% O_2 led to a slightly lower firmness value compared to that obtained in December. Where as in December there had been no significant effect of shelf life on fruit firmness, the value fell by about 0.5kg over the seven days.

As in December fruit stored in 8% CO_2 showed a marked effect of delayed harvest with fruit picked two weeks later being a kiolgramme softer than that picked on the 16th of September. Storing fruit for an extra eight weeks in 8% CO_2 gave rise to a significant fall in fruit firmness with the effect being larger with delayed harvest. The most pronounced effect was that of storage regime on shelf life. Fruit samples from 8% CO_2 fell by about 2 kilogrammes during the seven day shelf life period.

Once again there was no significant effect of picking date, storage regime, or shelf life on fruit background colour or sugar content. Internally the level of storage disorders increased significantly with different storage regimes. Where as Core Flush and Senescent Breakdown were almost absent from samples of fruit from 5% CO_2 1.2% O_2 levels were very high in all the samples from 8% CO_2. The incidence of both Core Flush and Senescent Breakdown increased with delayed harvest or after the seven day shelf life period. The level of fungal spoilage in all samples even after shelf life was very low.

6 SUMMARY

(i) Cox

The results from the previous five years of the maturity programme had shown a significant variation in fruit firmness between sites and proposed marketing periods. Using this information the QFG has refined its picking date guidelines to ensure fruit with the best flavour and eating quality is available from late September to March. Comprehensive guidelines were produced by the group at the beginning of September for early, average and late sites and for long, medium and short-term storage. Table 18 shows the predicted dates fruit firmness would reach 8.6, 8.0 and 7.5kg and a starch pattern of 70% for early, average and late sites and the actual dates calculated using data collected from the marker orchards.

TABLE 18: The predicted and actual dates fruit firmness reached 8.6, 8.0, 7.5kg and a starch pattern of 70% for early, medium and late sites based on starch pattern.

	Early		Medium		Late	
	Predicted	**Actual**	**Predicted**	**Actual**	**Predicted**	**Actual**
8.6kg	06/09	07/09	08/09	11/09	11/09	18/09
8.0kg	11/09	14/09	13/09	18/09	16/09	25/09
7.5kg	15/09	20/09	17/09	25/09	20/09	30/09
70%	06/09	28/08	08/09	01/09	11/09	13/09

The predicted dates were obtained using data collected from the marker sites during August, and the average rate of change in fruit firmness and starch pattern found in the previous five years of the study.

There was a good agreement between the actual and predicted date fruit firmness reached 8.6kg at the early sites. However because fruit firmness did not decline as rapidly in 1999 as the previous five years the actual and predicted dates become further apart for the medium and late sites and lower firmness values at harvest.

By contrast the actual starch pattern of 70% occurred significantly earlier than predicted, especially at the early and medium sites.

Using the data from the storage assessments the latest data fruit could be harvested at each site and have a firmness of 6.5kg after storage in 1.2%O_2 until early March, mid January or in air until mid October was found, Table 19.

TABLE 19: Latest date fruit could be harvested and still have a firmness of 6.5kg after storage in 1.2% O_2 until early March, mid January or air until mid October. (Last year's dates in brackets).

Site	Early-March	Mid-January	Mid-October
K1	<02/09 (14/9)	02/09 (21/9)	16/09 (21/9)
K3	02/09 (14/9)	09/09 (14/9)	17/09 (28/9)
K7	09/09 (14/9)	16/09 (21/9)	27/09 (21/9)
K10	09/09 (21/9)	16/09 (21/9)	02/10 (21/9)
K11	09/09 (07/9)	16/09 (21/9)	29/09 (>28/9)
K12	09/09	16/09	23/09
K13	02/09 (07/9)	02/09 (14/9)	17/09 (14/9)
E4	09/09 (14/9)	16/09 (21/9)	26/09 (>28/9)
SF2	16/09 (21/9	16/09 (>28/9)	26/09 (>28/9)
SF5	09/09 (14/9)	16/09 (14/9)	19/09 (14/9)
N3	02/09 (21/9)	16/09 (21/9)	19/09 (>28/9)
WM4	16/09	>23/09	N/A
WM5	09/09	>23/09	02/10
WM7	16/09	>23/09	01/10

(ii) Conference

Fruit size was generally good and during the first week of the study increased by almost 5.0mm the subsequent rate of 2.5mm a week was similar to previous years.

Soluble solids increased by about 0.1% a day and at 14% by the end of August was average for the variety. The concentration of soluble solids in fruit from all harvest dates was sufficiently high to provide good eating quality.

Fruit firmness fell at a steady rate during the entire study and at about 0.5kg a week was similar to the previous six seasons. Initial fruit firmness at 7.4kg was the lowest recorded in the six years of the study.

The starch pattern declined very rapidly, 3.3% a day during the first week of the study.

In 1999 the correct harvesting dates determined by measurements made on samples picked on the 2nd, 9th, 16th and 23rd September and stored in air at -0.5 to -1°C was before the 2ndof September for 32 weeks storage and 16th September for 18 weeks storage. These dates coincide with a Streif index of 1.0 and 0.7.

The results from the first five years of the programme had suggested that the Optimum Harvest Date for the long term storage of Conference pears conformed to a Streif index of 0.7. This figure was confirmed by the 1999 results for fruit to be stored for up to 18 weeks. However for long-term storage, up to 32 weeks the index had to be above 1.0 in the 1999 season.

The picking for long-term storage should start as soon as fruit has sufficient size and the average soluble solids are above 12% and be concluded before the index falls below 0.7 for short-term and 1.0 for long-term storage.

(iii) Gala

Fruit maturity developed about four days earlier in 1999 compared to 1998.
Fruit size was generally very good and increased by about 3mm a week. However there was a significant difference, 21 days, between the dates when fruit from the four sites reached 65mm.This difference was mainly due to crop load and at one site the starch pattern fell below 90% before the average size reached 65mm.

Background colour changed very rapidly once the starch pattern started to fall.
Soluble solids were good and increased by 0.1% a day this was similar to 1998.

The average fruit firmness fell by about 0.1kg a day this was similar to previous years.
In contrast to Cox there was no large fall in the starch pattern during August. Once the starch pattern did fall it continued at a steady rate of 3% a day.

Harvest date only had a small effect on fruit firmness either immediately ex-store or after shelf for fruit stored in 5% CO_2 1.2% O_2 after 14 weeks. All samples were above 7.5kg. Fruit stored in 8% CO_2 for 14 weeks showed a decline in fruit firmness both immediately ex-store and more noticeably after seven days shelf life. Only fruit picked on the 16th was above 7.0kg.

There was little change in fruit firmness 8weeks later for samples stored in 5% CO_2 1.2% O_2. Delaying the harvest slightly reduced the firmness both immediately ex-store and after shelf life. However all samples were above 7.0kg.

Storing fruit for an extra eight weeks in 8% CO_2 had a marked effect on reducing fruit firmness. The effect was more pronounced with delayed harvest and after shelf when even samples picked on the 16th of September were well below 6.0kg.

Samples stored in 8% CO_2 for 22 weeks developed core flush. This was aggravated by delayed harvest and shelf life.

The results from the 1999 harvest confirm the findings of Dr John Stow that Gala for long term storage has to be harvested before the average starch pattern falls below 50%.

The storage trial under taken by the QFG in 1999 involving four sites, supported the storage recommendations published by David Johnson. The use of high levels of CO_2 even at low storage temperatures has a marked effect on shelf life, and should not be used after mid-November. If scrubbed storage facilities are not available then fruit should be held in air at 0^0C.