

<b>Title</b>	Maximise the potential of A931/15 (Meridian) and E11/20 (Park Farm Pippin) for UK conditions
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## **Grower summary ('Meridian')**

- 'Meridian' fruit harvested with a firmness of 7.2-7.5 kg achieved an ex-store firmness above the supermarket threshold of 6.5 kg in January and March.
- At 3.5-4.0°C fruit firmness was maintained until January in CA conditions (CO<sub>2</sub>/O<sub>2</sub>) of <1/1.2 and until March in 5/1.
- At 1.5-2.0 °C fruit firmness retention was better but low temperature breakdown (LTB) developed in 5/1.
- Early indications are that CA storage in <1/1.2 at 1.5-2.0°C may be the most favourable regime (easier to achieve than 5/1) for Meridian destined for the January-March market but further experience of storing at 1.5-2.0°C is required to ensure that LTB is not a problem.

### **Note on E11/20 ('Park Farm Pippin')**

In view of the decision by the APRC not to release E11/20 as a commercial variety, further research into maximising its potential for UK conditions was not justified.

# Experimental Section

## Background & Introduction

Progress towards identifying the optimum picking date and storage conditions for Meridian was outlined at the East Malling Research Association Top Fruit Storage Day held on 28 March 2002. The audience was reminded that Meridian has the right attributes to be a successful dessert apple in the market place. Information supplied by the HRI Apple and Pear Breeding Club upon release of Meridian in 1999 focussed on the following important attributes:

- Meridian is well liked by consumers and meets their top three requirements: taste, flavour and quality.
- Meridian fruit is attractive, very juicy with good fruit size.
- In trials, Meridian cropped 30% more than Queen Cox and with more Class 1 fruit.

It is clear from discussions held with marketing groups that the marketing 'slot' anticipated for Meridian is post-Christmas, possibly January or February. One of the difficulties in storing Meridian for this length of time is the lack of firmness. It appears that multiple retailers are unlikely to accept consignments of fruit that register penetrometer readings below 6.5 kg. Results of previous storage experiments indicate a possibility of achieving the required firmness threshold where fruit is picked sufficiently early and held in CA conditions of 5% CO<sub>2</sub> and 1% O<sub>2</sub> (see Report to 31 March 2001). In the previous report (see Report to 31 March 2002) the following conclusions were made:

- Firmness of CA-stored fruit was maintained at or above the suggested (supermarket) threshold of 6.5 kg (63.8 N) by harvesting fruit with a firmness value of 7.1 kg (70 N) or above.
- Storage in a 5/1 or <1/1.2 (%CO<sub>2</sub> / %O<sub>2</sub>) CA regime at 3.5°C provided adequate firmness in fruit stored until January but 5/1 was necessary to provide fruit to the required firmness specification in March.

Since starch pattern and internal ethylene concentration are poor indicators of maturity for harvesting for storage (both change too late to be of practical use) fruit firmness is likely to be the prime indicator of harvest date. Current advice is to harvest when firmness has declined to 70-75 N (7.1-7.6 kg). Picking too early is to be avoided if adequate size and red colour are to be achieved and eating quality in terms of taste and flavour maximised. Although multiple retailers may not be looking for heavily coloured fruits there may be a requirement for 25% surface colour and 2-3 background colour (Worldwide Fruit colour chart).

### Storage trials 2002/2003

Having established the criterion for harvesting Meridian to achieve the required firmness ex-store it was decided to evaluate the potential benefit of storing Meridian in CA conditions at lower temperatures. Clearly any benefit in terms of fruit firmness would be particularly significant and may allow a slight delay in harvest to achieve higher eating quality ex-store. Lower storage temperatures may obviate the need for 5/1 storage. It would be beneficial if 'Cox type' (<1/1.2) conditions proved sufficient for the storage of fruit until February as facilities for this type of storage are more available within the industry. In experiments carried out in 1999 and 2000 firmness of air-stored fruit was retained more effectively at lower storage temperatures of 0°C and 1.5°C than at 3.0°C but low temperature breakdown occurred at 0°C after 3 months.

### Materials & Methods

Meridian apples were harvested on two occasions from the same two sites in East Kent and Suffolk that were used as sources of fruit for storage experiments carried out in 1999, 2000 and 2001. Although according to the starch and ethylene data the fruit from both sites and picks were unripe the firmness was just above the 70 N (7.1 kg) required for long-term storage (Table 1). Fruit was stored in 5/1 and <1/1.2 regimes at storage temperatures of 1.5-2°C and 3.5-4°C. Fruit samples were removed from store on 7 January and 4 March 2003. Immediately after removal the samples were weighed prior to measurement of the firmness of the fruit and of the soluble solids concentration of the juice. The fruits were then cut and examined for the presence of internal disorders such as bitter pit and low temperature breakdown. An additional set of samples was placed into a room at 20°C for 7 days and then assessed as described for fruit immediately ex-store.

**Table 1** Effect of picking date in September 2002 on harvest maturity parameters of Meridian apples from orchards in East Kent and Suffolk.

Firmness measured with an automated penetrometer; starch coverage determined using the iodine test, soluble solids measured using a refractometer and internal ethylene concentration measured by gas chromatography.

Site	Soluble solids (%)	Starch (% black)	Firmness		Internal ethylene concentration* (ppb)
			(N)	(Kg)	
<i>East Kent</i>					
1st pick 2/9/02	12.2	100	73.9	7.5	26.3
2nd pick 9/9/02	12.7	96	73.0	7.4	51.6
<i>Suffolk</i>					
1st pick 3/9/02	11.3	100	72.0	7.3	18.5
2nd pick 10/9/02	11.9	98	70.4	7.2	16.1

\* Ripening threshold approximately 100 ppb

## **Results & Discussion**

### *Fruit firmness*

Generally all fruit achieved the desired level of firmness (6.5 kg or 63.8N) when stored until January regardless of orchard site, picking date and storage conditions (Table 2). However, when storage at the higher (recommended) temperature of 3.5-4°C was extended to March only fruit stored in the 5/1 regime achieved the required firmness. The firmness of fruit from both orchards and both picking dates stored in 5/1 at 3.5-4°C until March was 6.5 kg (63.8N) or above. Reducing the storage temperature to 1.5-2°C generally improved the firmness of fruit held in both the 5/1 and <1/1.2 regimes until January and March particularly in fruit held for a further 7 days at 20°C. Most importantly the firmness of fruit held in the <1/1.2 regime at the lower temperature until March was 6.5 kg (63.8N) or above regardless of orchard site or picking date.

**Table 2** The effect of picking date and storage conditions on the firmness (N) of Meridian apples from orchards in Suffolk and East Kent.

Fruit samples were stored in an atmosphere of 5% CO<sub>2</sub> + 1% O<sub>2</sub> or <1% CO<sub>2</sub> + 1.2% O<sub>2</sub> (balance nitrogen) until 7 January and 4 March 2003. Figures in brackets refer to fruit kept for a further 7 days at 20°C to simulate a marketing period (SMP). Picks 1 and 2 refer to fruit picked on 2/3 and 9/10 September 2002 respectively. Shaded areas indicate where ex-store firmness was at or above the required threshold of 63.8N (6.5kg).

Orchard	Pick	CO <sub>2</sub> / O <sub>2</sub>	Fruit firmness (N)		Fruit firmness (N)	
			Stored until January 2003		Stored until March 2003	
			3.5-4°C	1.5-2°C	3.5-4°C	1.5-2°C
Suffolk	1	<1/1.2	65.5 (63.4)	66.8 (72.7)	56.2 (52.0)	64.3 (60.1)
	1	5/1	69.4 (65.3)	69.5 (71.6)	65.6 (56.8)	68.8 (63.7)
	2	<1/1.2	63.1 (63.6)	65.2 (70.7)	51.9 (50.3)	63.9 (59.8)
	2	5/1	66.3 (66.4)	67.4 (70.9)	64.9 (58.3)	65.4 (63.0)
East Kent	1	<1/1.2	67.5 (65.6)	67.8 (71.8)	61.3 (58.6)	66.9 (63.3)
	1	5/1	67.8 (63.8)	67.7 (72.9)	66.1 (58.9)	69.4 (63.3)
	2	<1/1.2	65.4 (63.1)	66.6 (67.3)	58.3 (55.0)	63.8 (58.6)
	2	5/1	65.3 (61.4)	67.0 (68.1)	63.9 (55.1)	65.7 (63.4)

A motorised penetrometer was used to test fruit immediately ex-store but problems with this instrument necessitated the use of a Lloyd LRX texture analyser for testing January fruit after a SMP.

### *Soluble solids concentration*

At harvest the average soluble solids concentrations in the fruit from the Suffolk and East Kent orchards were 11.6 and 12.5% (see Table 1). Further conversion of starch to sugar during storage until January 2003 resulted in an increase in soluble solids concentration of about 2 and 2.8% in fruit from the Suffolk and East Kent orchards respectively (Table 3). Soluble solids concentrations declined slightly by about 0.3-0.4% where storage was extended to March. There was generally little effect of storage conditions on the concentration of soluble solids in the fruit after storage but Suffolk fruits were on average 1.7% lower in soluble solids ex-store than East Kent fruit.

**Table 3** The effect of picking date and storage conditions on the concentration (%) of soluble solids in Meridian apples from orchards in Suffolk and East Kent.

Fruit samples were stored in an atmosphere of 5% CO<sub>2</sub> + 1% O<sub>2</sub> or <1% CO<sub>2</sub> + 1.2% O<sub>2</sub> (balance nitrogen) until 7 January and 4 March 2003. Figures in brackets refer to fruit kept for a further 7 days at 20°C to simulate a marketing period (SMP). Picks 1 and 2 refer to fruit picked on 2/3 and 9/10 September 2002 respectively

Orchard	Pick	CO <sub>2</sub> / O <sub>2</sub>	% Soluble solids		% Soluble solids	
			Stored until January 2003		Stored until March 2003	
			3.5-4°C	1.5-2°C	3.5-4°C	1.5-2°C
Suffolk	1	<1/1.2	13.3 (12.9)	13.2 (13.3)	13.3 (12.9)	13.4 (12.6)
	1	5/1	13.5 (13.6)	13.3 (13.5)	13.4 (12.9)	13.5 (13.0)
	2	<1/1.2	13.8 (13.7)	14.0 (13.3)	13.1 (13.0)	13.8 (13.3)
	2	5/1	13.8 (13.9)	13.9 (13.7)	13.4 (13.5)	13.6 (13.1)
East Kent	1	<1/1.2	15.2 (15.5)	15.5 (16.1)	14.6 (15.2)	15.3 (15.1)
	1	5/1	15.2 (15.2)	15.3 (15.6)	14.6 (14.8)	15.4 (14.6)
	2	<1/1.2	15.3 (15.4)	15.5 (15.0)	14.7 (14.8)	14.9 (14.6)
	2	5/1	14.7 (15.1)	15.3 (15.4)	15.5 (14.8)	15.1 (15.1)

### *Rotting and physiological disorders*

There was a very low susceptibility of fruit to rotting and bitter pit with an average incidence of 1% or less (data not presented). An unusual disorder affected the skin of apples from the East Kent orchard particularly those from the second harvest (data not presented). Brown sunken lesions were noted on the fruit on removal from store (Figure 1). Samples were taken in torrential rain and it is suspected that the cause may have been damage inflicted to the fruit during sampling and transport to East Malling possibly as a result of moisture present on the fruit at the time of picking. Abrasions of this type have been reported in the literature particularly where fruit had been transported after application of calcium solutions. Damage had not been noted on fruit from this orchard sampled in the 3 previous years.

**Figure 1.** Damage symptoms on Meridian apples harvested from the East Kent orchard on 9 September 2002 and stored in controlled atmosphere conditions until January 2003.



Low temperature breakdown was generally restricted to fruit stored until March at the lower storage temperature of 1.5-2°C and occurred only in fruit from the 5/1 CA regime (Table 4). Fruit from both orchards were affected and the incidence of the disorder increased markedly during a further 7 days at 20°C.



**Table 4** The effect of picking date and storage conditions on the incidence (%) of low temperature breakdown (LTB) in Meridian apples from orchards in Suffolk and East Kent

Fruit samples were stored in an atmosphere of 5% CO<sub>2</sub> + 1% O<sub>2</sub> or <1% CO<sub>2</sub> + 1.2% O<sub>2</sub> (balance nitrogen) until 7 January and 4 March 2003. Figures in brackets refer to fruit kept for a further 7 days at 20°C to simulate a marketing period (SMP). Picks 1 and 2 refer to fruit picked on 2/3 and 9/10 September 2002 respectively.

Orchard	Pick	CO <sub>2</sub> / O <sub>2</sub>	Incidence (%) of LTB		Incidence (%) of LTB	
			Stored until January 2003		Stored until March 2003	
			3.5-4°C	1.5-2°C	3.5-4°C	1.5-2°C
Suffolk	1	<1/1.2	0 (0)	0 (0)	0 (0)	0 (0)
		5/1	0 (0)	0 (0)	0 (0)	12.5 (35)
	2	<1/1.2	0 (0)	0 (0)	0 (0)	0 (0)
		5/1	0 (0)	0 (0)	0 (0)	12.5 (52.5)
East Kent	1	<1/1.2	0 (0)	0 (0)	0 (0)	0 (0)
		5/1	0 (0)	0 (2.5)	0 (0)	5.0 (45.0)
	2	<1/1.2	0 (0)	0 (0)	0 (0)	0 (0)
		5/1	0 (0)	0 (0)	0 (0)	2.5 (42.5)

## **Conclusions**

- Firmness of fruit stored in CA (5/1 or <1/1.2) until January was maintained at or above the suggested (supermarket) threshold of 6.5 kg (63.8 N) by harvesting fruit with a firmness value of 7.2-7.5 kg (70.4-73.9 N).
- Although storage in a 5/1 or <1/1.2 CA regime at 3.5-4°C provided adequate firmness in fruit stored until January, only 5/1 provided fruit of the required firmness specification in March.
- Maintaining a lower storage temperature of 1.5-2°C resulted in a greater retention of firmness in fruits kept in 5/1 and <1/1.2 but the development of low temperature breakdown in the 5/1 regime would preclude the use of the lower storage temperature.
- Fruit kept in the 'Cox-type' CA conditions of <1/1.2 at the lower temperature were as firm as those kept in the more stringent 5/1 regime at the higher temperature.
- It appears that lower storage temperatures may obviate the need for 5/1 storage. This would be beneficial to the UK industry since 'Cox type' (<1/1.2) conditions are more available within the industry.
- Unlike in the previous year (see Report to 31 March 2002) bitter pit was not a problem in the fruit stored in 2002-03. This may in part be due to the emphasis given to the use of calcium sprays as a means of preventing the problem and to the increasing age of the trees.
- Soluble solids (sugar) levels in fruit ex-store were sufficiently high to provide good eating quality regardless of orchard site and harvest date.

## **Further testing and evaluation**

As commented on in the previous report (Report to 31 March 2002) the threshold level of firmness that provides satisfactory eating quality in Meridian apples has not been established. The impression is that Meridian eats well at a lower penetrometer value than Cox. It is important to establish the required firmness using mechanical tests, as this will affect the time of harvesting and the selection of suitable storage conditions. Any delay in harvesting that can be accommodated and the use of less stringent CA conditions are likely to generally improve eating quality. Similarly, decisions regarding the marketing 'slot' for Meridian will have major effects on the time of harvest and the type of storage that is required. Current indications are that the marketing 'slot' for Meridian is in February/March and that the firmness requirement is similar to that for Cox i.e. 6.5 kg (63.8N). The work within SP117 has been geared towards realising this objective. The work done in 2002-03 shows that there is a prospect of using storage temperatures lower than for Cox (3.5-4°C). Although low temperature breakdown did not occur in fruit stored in 'Cox type' (<1/1.2) conditions at 1.5-2°C until March there needs to be further years of testing before a change can be made in the storage recommendations. Susceptibility to low temperature breakdown varies from orchard to orchard and from season to season and only after storing fruit from a range of orchards in a number of seasons can the robustness of storage recommendations be truly tested.