Project title:	A new technique for measuring the textural quality of apples
Project number:	TF 132 [Previously APRC SP 132]
Report:	Annual report 2001/2002
Project leader:	C J Dover, HRI East Malling
Key words:	apple, textural quality

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ANNUAL PROJECT REPORT FOR 2001/2002

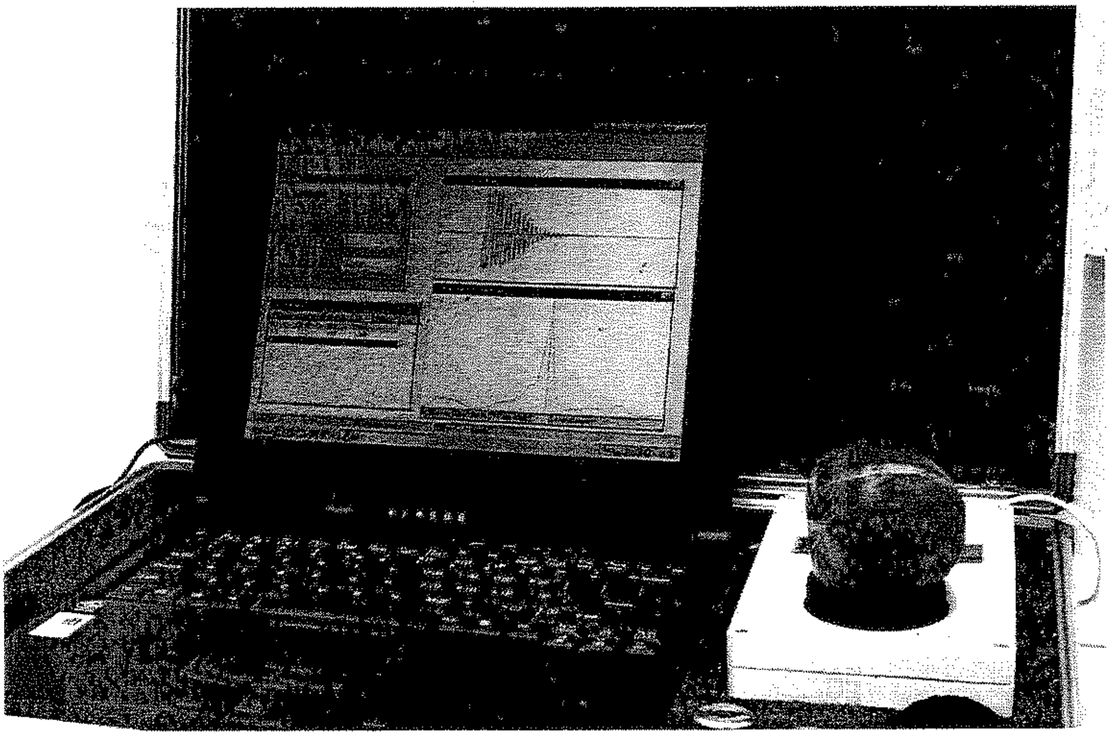
Customer, Project Code and Title:	EM Trust & APRC (IAS 32164) A new technique for measuring the textural quality of apples
Project Leader:	C J Dover
Income:	£28.4K - EM Trust £10,000 - APRC
Commodity Area:	Top Fruit

Background

In the first year of the project, a laboratory-prototype instrument that provides a measure of the fracture properties of the fruit was designed, built and tested. The instrument consists of a blade, the ends of which are fixed to shafts so that the blade can be rotated about the axis of its sharp edge. An apple is tested by pushing it, from the stalk end, onto the blade to a fixed insertion depth. A pulley, on the end of one of the shafts, is connected to the load cell of a Lloyd LRX materials testing machine by a steel band. As the crosshead of the LRX moves upwards, the pulley and hence the blade rotates; the apple is prevented from rotating by hand. The intention was to test the technique in a well-controlled manner, rather than to produce an instrument in a form that could be used commercially. A hand-held or simplified bench mounted device could be developed subsequently.

A whole-apple wedge test was evaluated as an alternative measure of fracture properties. It was considered that the insertion of a wedge (of length greater than the diameter of the fruit) into a whole apple would produce similar forces to those occurring during the twisting of a blade and result in a similar mode of failure. This whole-apple wedge test has the prospect of being simpler to implement than the blade test, although the blade test may still have some advantages as it might be feasible to develop a hand-held device for the blade test but not for the wedge test. The ability of these techniques to discriminate between samples of apples covering a wide range of mechanical properties, was shown, and was improved by correcting for fruit size.

This report covers the second year of the 3-year project, which has been concerned with the relationships between the mechanical measures and the sensory perception of texture. Additional funding was provided by APRC to include an assessment of 'acoustic firmness' as measured by an AFS unit (on loan from AWETA BV). When an apple is placed on the measurement cup (as shown below) it receives an impact from a round-ended plunger. The resulting sound is analysed to determine the main resonant frequency and the fruit weight is recorded, these are used to calculate a 'firmness index'.



Experimental details

Apple samples covering a wide range in texture were produced by storage in different regimes and by using two varieties. To determine the effect of fruit size on the mechanical measures, fruit were graded into 3 size bands prior to storage.

Treatment and measurement details 2001/02

- Cox in 3 size bands: 60-65, 65-70, 70-75mm diameter. Three storage regimes: 0/1.2, 0/2, 0/3 (% CO_2/O_2)
- Gala in 3 size bands: 65-70, 70-75, 75-80mm diameter. Three storage regimes: 0/1, 0/2, 8/13 (% CO_2/O_2)
- Measurements: blade, whole-apple wedge, sensory panel, penetrometer, juice extraction, and 'acoustic firmness'.

Measurements were made on three replicate sets of samples to correspond with three sensory panel sessions. Separate samples were used for each measurement except; juice was extracted from fruit used for the penetrometer measurement and 'acoustic firmness' was measured on all samples of fruit. Diameter and height were recorded for each fruit used for the blade and whole-apple wedge tests. The sensory assessments were carried out by a trained sensory panel at Leatherhead Food Research Association.

Results and Discussion

The results presented here are from a preliminary analysis of the data collected. A detailed analysis will be carried out early in the third year of the project. Increasing the oxygen concentration in the storage atmosphere of Cox apples reduced the maximum torque in the blade test and the maximum force in the whole-apple wedge test (Figs 1 and 2).

As expected, there was a clear effect of fruit size on this measurement. For a given tissue strength, a greater force will be required to break a larger apple. Determining a correction for fruit size will form part of subsequent data analysis. The sensory assessment of crispness showed a similar overall trend with oxygen concentration, but without a consistent effect of fruit size (Fig. 3). Penetrometer measurements showed a general decline with increasing fruit size (Fig. 4), the effect of oxygen concentration was greater between 1.2 and 2% than between 2 and 3%. A decline in acoustic firmness index with increasing oxygen concentration was observed (Fig. 5), though with an apparent reduced sensitivity compared to the mechanical measures.

For Gala apples, the effect of fruit size on maximum force in the whole-apple wedge test tends to mask the effect of storage atmosphere (Fig. 6). An allowance for fruit size is required before comparisons with sensory attributes can be made. Similar trends with storage atmosphere for sensory crispness and penetrometer measurements (Figs 7 and 8) were observed, though there was a clear trend of declining values with increasing fruit size for the penetrometer which was not evident for sensory crispness. Storage in 8% carbon dioxide and 13% oxygen (8/13) appeared to be as effective as storage in 1% oxygen in maintaining sensory crispness. However, these measurements were carried out 'ex-store' and not after a simulated marketing period, during which fruit stored in 8/13 would be expected to soften rapidly. There appeared to be little effect of storage atmosphere on acoustic firmness index for this variety (Fig. 9).

When data for the two varieties is combined (using a limited data set), there appears to be a good relationship between penetrometer reading and sensory crispness for values below ~60N, though less good above 60N (Fig. 10). The relationship between 'acoustic firmness' and sensory crispness appears poor (Fig. 11), as does that between 'acoustic firmness' and penetrometer reading particularly between 60-70N (Fig. 12). However, a detailed analysis of the data is required before the relationships between sensory attributes and the mechanical and other measures can be established with any confidence.

Future work

In the third year of the project, the applicability of the new techniques will be established over a wide range of apple textures using different varieties of fruit.

Fig. 1. Maximum torque (Blade test) for Cox stored in different atmospheres

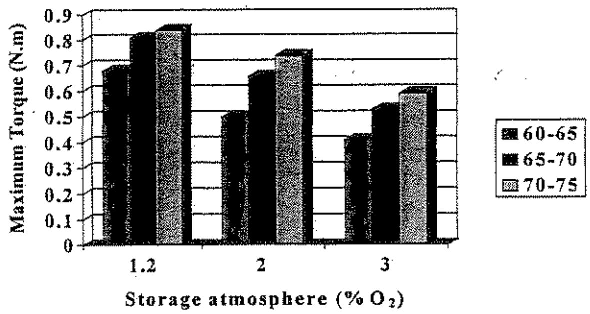


Fig. 2. Maximum force (Wedge test) for Cox stored in different atmospheres

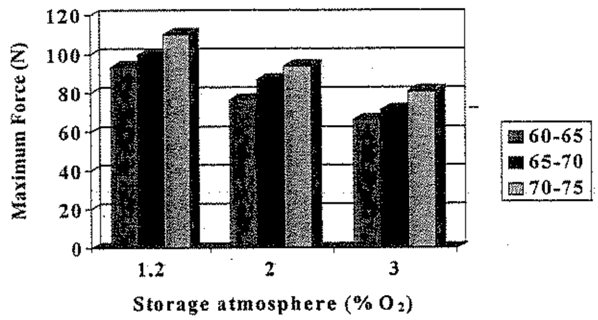


Fig. 3. Sensory Crispness for Cox stored in different atmospheres

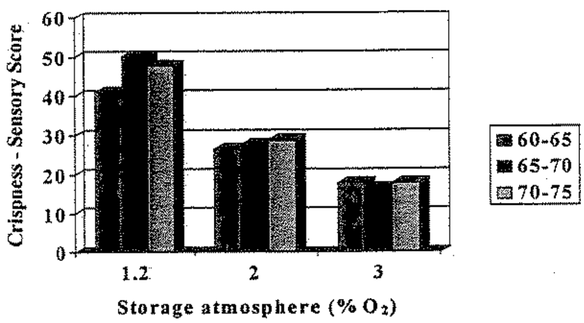


Fig. 4. Penetrometer measurements on Cox stored in different atmospheres

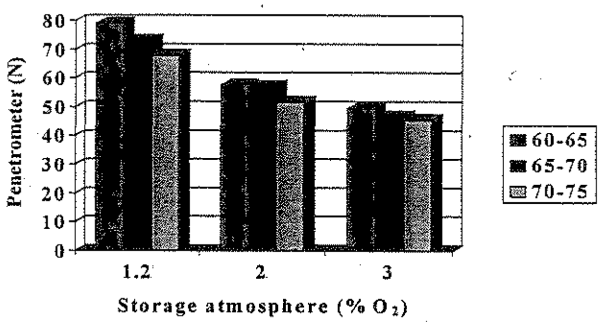


Fig. 5. Acoustic firmness measurements for Cox stored in different atmospheres

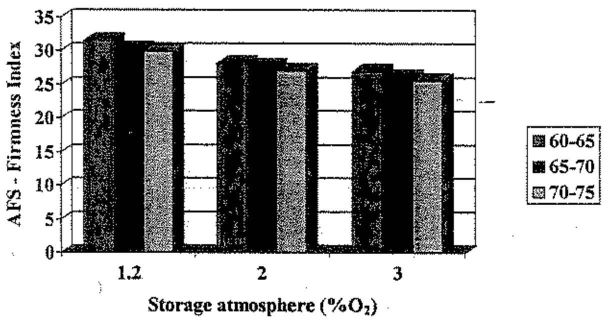


Fig. 6. Maximum force (Wedge test) for Gala stored in different atmospheres

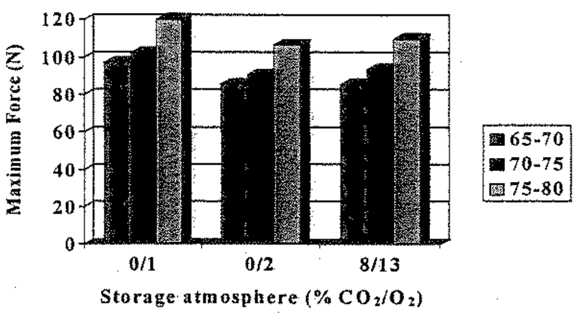


Fig. 7. Sensory Crispness for Gala stored in different atmospheres

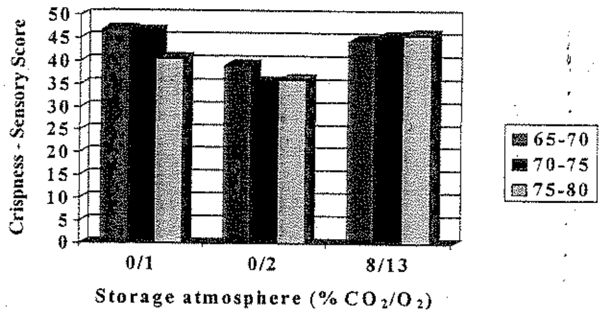


Fig. 8. Penetrometer measurements for Gala stored in different atmospheres

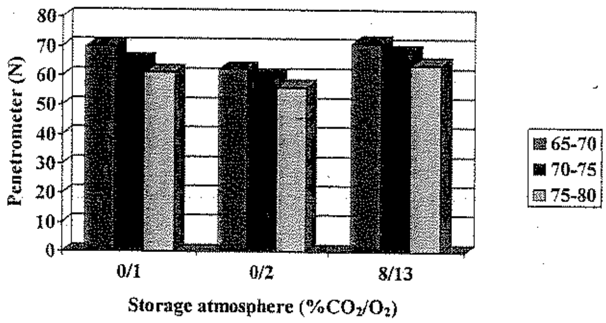


Fig. 9. Acoustic firmness measurements forGala stored in different atmospheres

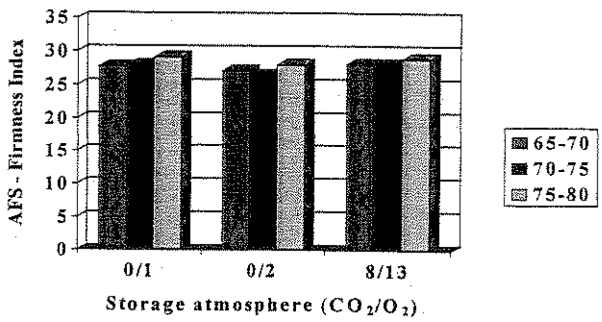


Fig. 10. Penetrometer against Sensory Crispness

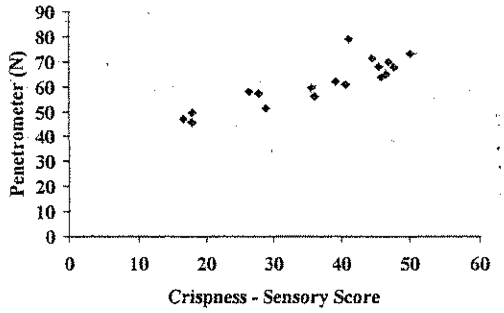


Fig. 11. Acoustic firmness against Sensory Crispness

Fig. 12. Acoustic firmness against penetrometer