Project title:	**Developing strategies for using chlorophyll fluorescence to assess maturity and physiological stress in apples**
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Grower Summary

1. Headline

Chlorophyll fluorescence has been shown to be a potential non-destructive method to assess harvest maturity. However a novel strategy for predicting physiological damage during storage was found to be unsuccessful for Cox apples.

2. Background and expected deliverables

Chlorophyll fluorescence

Most leaves are green. However, if our eyes were more sensitive, we would also be able to see that they emit a low level of red light or fluorescence. Leaves contain chlorophyll which absorbs sunlight to drive the process of photosynthesis. Not all the absorbed energy can be used, and so the excess is re-emitted as fluorescence and heat. Over the past few decades scientists have learnt how to use the pattern of emitted fluorescence to obtain information about the mechanism of photosynthesis and the components that drive the process within the cells of the leaf.

Many fruits also contain chlorophyll, and are able to carry out photosynthesis, sometimes until fully ripe. Over the last decade there has been growing interest in using chlorophyll fluorescence to assess postharvest quality of fruit and vegetables. During this project we examined two aspects of apple and pear fruit quality in order to determine whether chlorophyll fluorescence can provide a non-destructive method of assessment. These two aspects are:

measurement of fruit maturity to predict and optimise harvest date; and
assessment of tissue stress/damage during long-term storage.

Chlorophyll fluorescence to assess fruit maturity.

Ripening of apples and pears is associated with a loss of starch, an increase in sugars and a softening of the tissues due to breakdown of cell walls. In addition, most varieties lose their green colour during ripening. This is a result of the progressive loss of chlorophyll, which is associated with a loss in the ability to photosynthesise. Whereas the loss of chlorophyll can be, and is, measured by scoring for colour changes, patterns of chlorophyll fluorescence can be used to assess not only chlorophyll levels, but also other components and processes of the photosynthetic system which are influenced by the levels of metabolites such as sugars and starch. Potentially, therefore, fluorescence could provide a more accurate measure of maturity than other non-destructive methods such as colour.

Chlorophyll fluorescence to assess fruit damage during long-term storage

One of the key components of the photosynthetic system is called photosystem 2 (PS2). This is a particularly important component as it is able to use sunlight to split water, releasing oxygen. However, the component is also very delicate and sensitive to many stresses. To maintain photosynthetic function the cell must be able to continually repair and rebuild PS2. Indeed, it has been estimated that on average each PS2 is repaired every 30 minutes in a photosynthesising leaf. Several researchers have used chlorophyll fluorescence to measure PS2 function and have tried to use this to assess tissue health. In this project we are taking a slightly difference approach. We deliberately damage PS2 with bright light and then measure the ability of cells to repair PS2. PS2 function does not directly affect fruit quality – we are merely using the ability to repair this component as a measure of tissue health. This strategy was developed during work on physiological damage in chilling sensitive commodities such as cucumbers and green peppers.

This project was a collaboration between NRI, EMR, FAST and Hansatech Instruments Ltd (HI) (a UK company that manufactures chlorophyll fluorimeters). Funding was provided jointly by HDC and HI.

3. Summary of the project and main conclusions

Chlorophyll fluorescence to assess fruit maturity.

A trial was conducted in collaboration with the Quality Fruit Group (QFG). For a selection of the orchards used by QFG a sample of fruit was assessed for fluorescence characteristics as well as normal quality characteristics. The specific aim was to see if maturity could be predicted by (modelled by) fluorescence characteristics alone.

- In a study conducted over two seasons and a selection of orchards, we have shown that there is a relationship between photosynthetic reaction centre density measured by chlorophyll fluorescence (RC/CS) and % starch levels (assessed by iodine staining) in Gala apples, Cox apples and Conference pears. We have shown a similar relationship with Streif index for Conference pears. These relationships are independent of season and orchard.
- A relationship can also be found between background colour and % starch for Cox and Gala. This is as strong as the relationship between RC/CS and %starch for Cox apples, but weaker for Gala. Background colour is very difficult to assess in Conference pears due to russetting, and was therefore not considered.
- The photosynthetic reaction centre density (RC/CS) was originally measured from apples which had been dark adapted for more than 30 minutes which makes the measurement cumbersome. However, we have shown that a similar pattern of decrease during ripening can be observed where the measurement is carried out without dark adaptation.

Together these findings suggest that chlorophyll fluorescence is potentially useful as a simple, rapid and non-destructive method to predict harvest maturity.

It would be particularly valuable to link this technology with another non-destructive technique able to give information about texture.

Chlorophyll fluorescence to assess fruit damage during long-term storage

Cox apples were stored at East Malling Research Station at normal CA (1.2% O_2) over a range of temperatures (4, 2, and 0ºC). At the lowest storage temperature we would normally expect to see low temperature damage, and the objective of the trial was to determine if we could see a loss of tissue health in advance of visible damage. Unfortunately, significant low temperature damage was seen only during the second season of trials.

The original hypothesis being tested was that the extent of PS2 recovery would decrease as the apples became stressed, and would indicate the point at which physiological damage occurred during long-term storage. The data gave some indications that this was happening in the lowest temperature (0ºC) store. However, the data from the lower temperature stores (2 and 4ºC) were so variable that the method did not clearly differentiate between treatments. Our conclusion is that although the strategy might be useful for commodities stored under very stressful conditions (e.g. chilling sensitive fruit during short-term low temperature storage) where damage might occur over a couple of weeks, it is not useful for apples where physiological damage occurs very slowly over several months.

4. Financial benefits

Not immediately applicable. Potential for commercialisation is to be discussed with Hansatech Instruments Ltd.

5. Action points for growers

None at this time.