CALCIUM IN APPLE FRUIT

Ian Ferguson
The Horticulture & Food Research Institute of New Zealand
Private Bag 92169
Auckland, New Zealand
iferguson@hortresearch.co.nz

The importance of calcium in apple fruit is its role in contributing to the maintenance of optimum quality during postharvest storage and fruit ripening. This role is seen directly in the prevention of specific disorders such as bitter pit, and in relationships between calcium and more general quality properties such as flesh firmness.

Recognition of the role of calcium has led to strategies for handling disorders and optimizing quality. These are of three kinds:

1. Postharvest treatments such as dips and drenches to increase calcium levels in the fruit during storage
2. Prediction schemes based on mineral analysis allowing identification of high-risk fruit, which can then be excluded from markets or treated postharvest.
3. Management of crop production which provides fruit at harvest with mineral nutrient levels sufficiently high and in balance that the fruit have a low risk of disorders and have optimal storage properties.

This third strategy is by far the most preferred. We should not be producing fruit predisposed to disorders or poor storage performance. The answer to many storage and quality problems is in managing the fruit on the tree.

We have used the calcium/bitter pit relationship in Cox's Orange Pippin and Braeburn fruit in New Zealand to sort out what influences calcium contents of fruit, with a view to provide both a prediction system, and advice to growers on how to optimize calcium contents of fruit during growth and development.

FRUIT ANALYSIS

Establishing a relationship between calcium and fruit quality depends heavily on the methods of sampling both fruit and fruit tissues.

- The variation in mineral contents between individual fruit on a tree is greater than in fruit from different trees.
- This variability should be minimized by sampling fewer fruit from more trees when sampling across an orchard block.
- There is also variation across or around a fruit, which can be minimized by sampling tissues from different parts of the fruit. In NZ, we mostly sample plugs of flesh tissue from under the skin, taking opposite tissue samples from the same fruit.

- Calcium/quality relationships are more likely to be established by sampling fruit from trees, for both storage quality and mineral analysis, than taking random samples from bulk harvested fruit.

PATTERNS OF MINERAL UPTAKE INTO FRUIT

Movement of calcium into developing fruit is rapid in the early stages of growth (Figure 1) but then often falls off, such that there may be little or no increase in calcium in the fruit over the later stages of growth. By contrast, potassium, and to a lesser extent magnesium, move into the fruit over the whole season, keeping up with fruit growth. This means that at maturity, calcium concentrations have fallen in the flesh, whereas potassium and magnesium concentrations may be steady or increase.

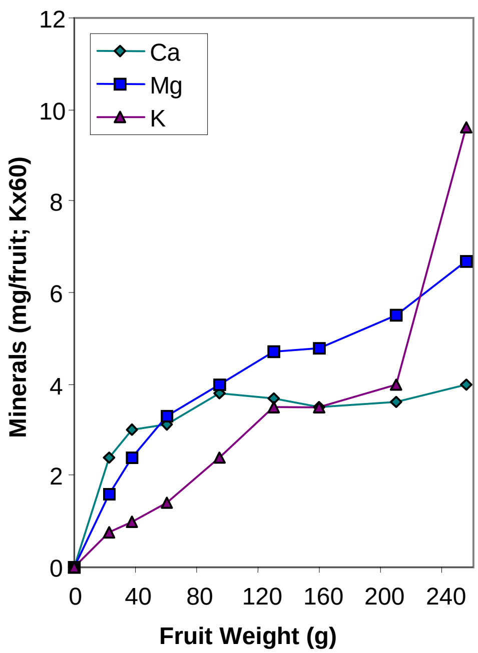

Figure 1. Uptake of Ca, Mg and K into developing Cox's Orange Pippin fruit. Data are for total content of the mineral in the fruit.

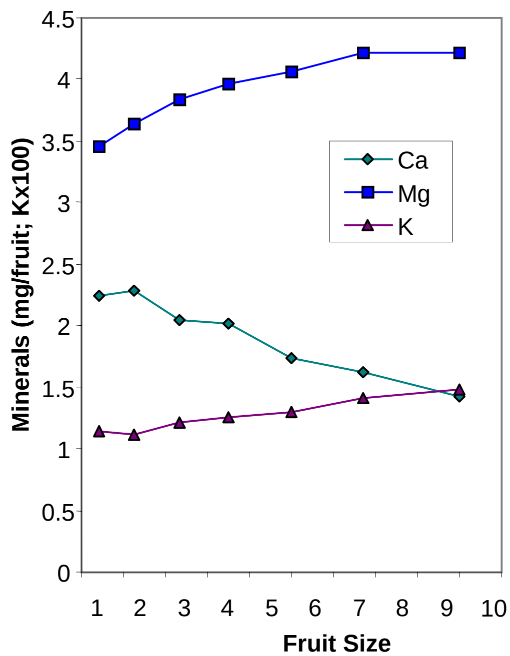

Figure 2. Concentrations of Ca, Mg and K in Cox's Orange Pippin fruit in relation to fruit size. On the X-axis, 1 represents small fruit (count 175) and 10 represents larger fruit (count 100).

This difference is reflected in the decrease in calcium concentration in fruit with increasing fruit size, in contrast to concentrations of potassium and magnesium (Figure 2). These patterns are the most common, but do not necessarily hold in every case. The net result is an often unfavorably low ratio of calcium to magnesium and potassium at fruit maturity. This can exacerbate development of calcium-related disorders.

FRUIT MATURITY

More mature fruit tend to develop less calcium-related disorders. This is probably because there is a ripening relationship with disorder development (e.g., bitter pit can be reduced or delayed using modified or controlled atmosphere storage), and rate of postharvest ripening is dependent on harvest maturity. This provides a strategy: high-risk fruit can be harvested later than low-risk fruit.

FRUITING WOOD

Calcium concentrations in fruit can differ according to the position of the fruit on the tree. Fruit from the upper parts of the tree usually have lower calcium contents. In different cultivars, fruit on older wood (e.g. 2 and 3 year old spurs) may have different calcium contents to those on one-year wood. Fruit on terminal positions may have higher calcium levels than those on lateral sites. This means that canopy management, including pruning and flower thinning, can be used to maximize production of high calcium fruit.

CROP LOAD

Light cropping trees have long been associated with large fruit prone to calcium-related disorders. We have found that crop load has a strong influence on quality, and this is not necessarily related to fruit size. Fruit from light cropping Cox trees had significantly lower calcium and higher potassium concentrations and more bitter pit than the same size fruit from medium to heavy cropping trees. This is probably due to differences in fruit to leaf ratios and fruiting positions. This means that control of crop load is an important feature in controlling quality.

POLLINATION

Poor pollination can be a problem in the Braeburn cultivar, and we have found that there is a relationship between low seed number, low calcium contents of the fruit, and high bitter pit and lenticel blotch disorder incidence. This suggests that attention to pollination will help optimize flesh calcium contents and postharvest quality.

AMELIORATION

Whilst the above factors provide ways in which to ensure that adequate calcium levels are achieved in mature apple fruit, both preharvest sprays and postharvest dip and drench treatments are available. These will increase calcium concentrations in the fruit flesh by, in some cases, up to 30%.

The most effective calcium compound is calcium chloride, although it can damage young leaves and fruit. Calcium nitrate is as effective, but is usually more expensive and can cause russet problems later in fruit development. There are a number of proprietary compounds available, some as foliar feeds, and others as specific agents for delivering calcium. The latter are usually buffered in order to reduce damage or may involve chelates. Our own experience is that none we have used are better than calcium chloride, although some may be as good, and be less damaging.

We have not found that there is a particular window during fruit growth in which it is more effective to apply calcium sprays. We recommend a regular schedule of spraying over the whole season, starting as early as possible without incurring damage. Postharvest dips and drenches are effective, but involve extra fruit handling, and the danger of calcium damage if heavy spraying has preceded harvest.

PREDICTION

We have had a prediction scheme based on fruit analysis in practice in New Zealand for many years. The format of this has changed over the years, as has the regulatory nature of it. At one stage, growers had to meet specified threshold levels of calcium for their fruit to be exported. This was modified by taking fruit size into account, and sometimes magnesium and potassium levels. This system was successful in maintaining an export market for our Cox fruit.

More recently, the onus has been on the grower to provide fruit of specified quality, with the grower taking the costs of fruit rejection at the market. Calcium targets are still in place, and growers use fruitlet analysis during the season as a guide to the way in which the fruit are developing. High-risk lines of fruit can be identified at harvest by analysis, and then treated with postharvest drenches.

CONCLUSIONS

Calcium is not the sole determinant of fruit quality, and must be used in conjunction with other indicators. However, it is one of the few quantitative measures that can be made before harvest to give an indication of disorder risk and postharvest behavior. Maximizing calcium concentrations in apple fruit, without incurring damage, will reduce risk of disorders and help in maintaining firmness and other desirable quality properties.

We cannot emphasize strongly enough the need to concentrate on the fruit on the tree in efforts to increase postharvest quality. There is increasing information available on the factors that influence fruit growth and quality properties, such that tree management must lie at the heart of quality fruit production. Quantitative measurements, monitoring, and subsequent management are the core of quality production.