Non-destructive testing for fruit quality assurance

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Fruit quality has been a key issue to growers and retailers throughout the history of the industry. The market for quality fruit has been growing rapidly over the last decade, increasing the value of premium produce. New marketing strategies, such as 'Ripe and Ready to Eat' and 'Eat Me Keep Me' fruit, aim to increase consumer consumption by guaranteeing fruit attributes are at their peak soon after purchase. In the past inferior quality fruit regularly found its way on to supermarket shelves, resulting in disappointed consumers. Standards were put in place by the EU to ensure poor quality produce was not sold to customers. These quality standards are used throughout the supply and distribution chain but rely on subjective measurement techniques and destructive sampling.

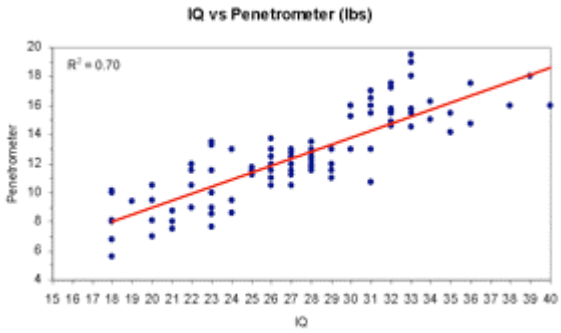
What is quality?

Fruit quality attributes such as size, freedom from defects, colour and firmness, can be measured by a number of different methods. The absolute reference point is the way a consumer perceives and interprets the quality of fruit. Each variety of fruit has unique characteristics that undergo sensory evaluation by the consumer during the eating experience to determine ripeness quality. The use of consumer sensory panels can be an important part of fruit quality assessment, as instrumental measures may lack sensitivity. A characteristic of great importance in most fruit tested by consumers is the texture. Texture not only relates to the structure when eating, but also the feel of the fruit externally. A typical consumer will test the firmness of fruit such as avocados or peaches before purchasing, gently squeezing by hand to decide ripeness quality. The need for an accurate and automated instrumental measure that can predict consumer judgements is driving scientists to further investigate the quality indices of fruit.

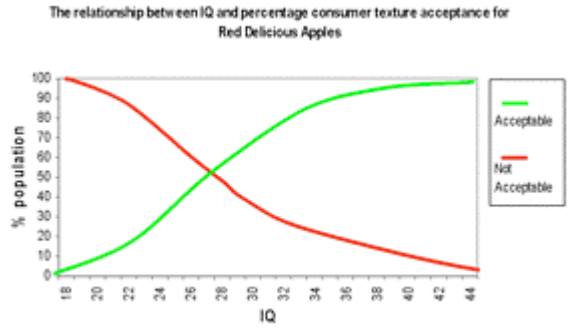
In addition to the on-line SIQ-FT system, Sinclair has produced a bench-top model for both research purposes and to compliment the on-line system as a commercial unit. This unit is based on the same non-destructive technology as the on-line system. Research scientists around the world are currently working with the bench-top system to improve fruit quality assurance testing and predict fresh produce storage times.

SIQ-FT: Correlation to consumer preferences and other instrumental measures

Studies have been carried out at Sinclair's UK research facility in Norwich to determine the relationship between SIQ-FT measurements and consumer judgements of fruit texture and quality. In conjunction with major packhouses around the world, research and trials have been carried out on a number of varieties of fruit. A typical trial will involve the firmness of a sample fruit being measured using the SIQ-FT, then tasting of the fruit by a panel of consumers who classify it in categories according to texture. Further trials use a trained sensory panel who score the fruit on a descriptor rating that is a characteristic of the fruit. Results indicate that the SIQ-FT segregates between sensory acceptance categories efficiently and correlates well with sensory descriptors such as



Historical ways of judging quality
The oldest method for assessing fruit quality, which is commonly used in packhouses today, is to feel the fruit by hand. By gently squeezing a piece of fruit, an instant estimation can be made about ripeness or quality. This however is a time consuming testing method and increases labour costs within a packhouse environment. This method led to the invention nearly 80 years ago of the first mechanical device to test fruit maturity and ripeness. The penetrometer was developed to give a numerical value for firmness and replace the method of applying pressure with the thumb. The penetrometer measures the force taken to sink a plunger to a set distance within the flesh of a fruit. The device can be operated by hand or mechanically. The Magness Taylor penetrometer is still widely used in the fresh produce industry to determine the firmness of many fruit varieties. The penetrometer is a destructive measure of firmness and is therefore limited to testing only a small proportion of the batch. This increases the chance of error within the quality control procedure, increasing the likelihood of inconsistent and poor quality fruit being shipped to the consumer



Non-destructive testing
Over the past decade considerable work has been put into developing non-destructive instruments to measure fruit quality attributes. One such measuring technique is Near Infra-Red (NIR), which estimates the total sugar and crunchiness. The performance of the SIQ-FT system in relation to mechanical measures has also been investigated, including the penetrometer, which is the industry standard for most fruit. The graph above shows the relationship between the SIQ-FT and penetrometer. The relationship between the two measures is strong even though the SIQ-FT measures a different attribute of fruit firmness.

SIQ-FT: Case Study – Apples
Sinclair's research findings have shown that the SIQ-FT can be used by fruit packers to simulate consumer judged acceptance categories with pre-determined cut-off values. The graph below shows results from recent trials carried out on Red Delicious applies using sensory evaluation. The apples were first assessed for firmness using the SIQ-FT. Each fruit was then tasted by panellists who were asked to rate the texture of the apples as either acceptable or unacceptable. The graph developed from the data shows the percentage of the population that found apples acceptable and the correlation with iQ values. The graph can be used to devise iQ firmness categories that are linked to consumer acceptability.

Sinclair International Ltd is currently compiling data for many varieties of apples to build an in-depth knowledge of how consumer acceptance levels relate to SIQ-FT measurements.

SIQ-FT Case Study – Avocados
In a further trial series, Sinclair tested the correlation between SIQ-FT measurements and consumer sensory descriptors for avocados. During the research, a consumer panel tested avocados and rated the fruit on a scale of 1 to 10 for a variety of sensory descriptors, such as creaminess. The external firmness of the avocados was assessed by gently squeezing the fruit and rating its firmness on a scale of 1 to 10. The relationship between the SIQ-FT and the penetrometer was also investigated and compared. The graphs also show how measurements from the SIQ-FT and traditional penetrometer relate to consumer panel judgements of external firmness and creaminess.

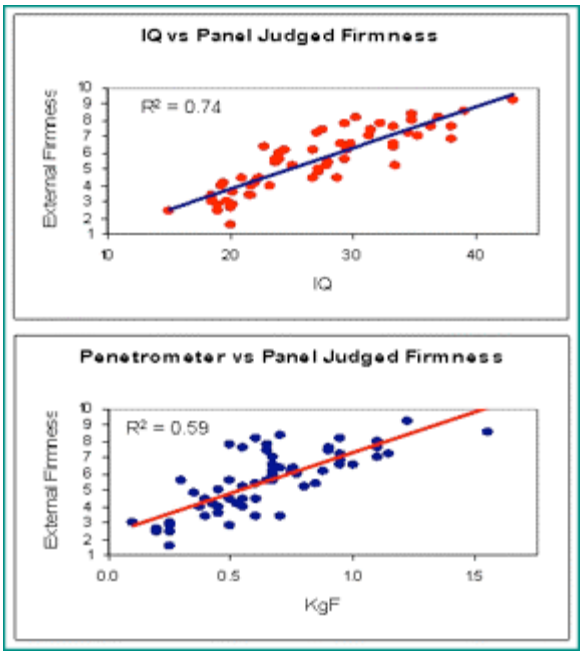
In this case, the SIQ-FT performed as well or better than the penetrometer for predicting panel-judged external firmness and creaminess. Overall the data shows that the SIQ-FT is a useful tool for assessing the attributes of avocados, that relate directly to consumer

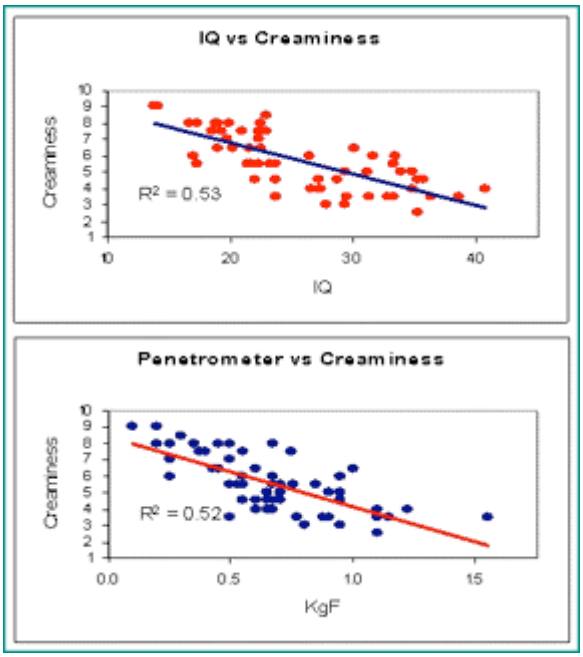
soluble solids held within fruit and grades it accordingly. NIR can be used on most varieties of fruit, although the calibration process requires continual attention when used on-line. Other imaging techniques can be used to grade fruit by assessing external colour and to discard fruit with external defects. Acoustical methods have recently been developed to measure the firmness of the fruit by tapping the surface and measuring the resonant frequency. This method can be used on apples and pears to assess firmness and internal defects, but implementation of this technology on-line and at high speed has obvious difficulties.

The Sinclair internal quality firmness tester

Sinclair International Ltd has a long history of working within the fruit industry, pioneering and developing advanced bellow systems of applying individual produce labels in packhouses around the world. Within the labelling industry, Sinclair has developed an extensive range of machines to suit a variety of packhouse applications. The company has now used its expertise and key research contacts to develop the Sinclair Internal Quality – Firmness Tester (SIQ-FT), a non-destructive on-line system currently being marketed by the Sinclair iQ divisions. The SIQ-FT tests every fruit on-line at commercial packing speeds of up to 600 fruit per minute, sorting the produce by firmness grade. The system also provides a 'real time' display and continuous record of firmness for every fruit tested. The SIQ-FT utilises four low-mass impact sensors, which touch each individual fruit on-line using Sinclair's patented bellows technology. The system assesses the firmness of every fruit and grades it accordingly. The sensors consist of a piezoelectric crystal that deforms on impact, producing a small voltage that can be used to assign iQ firmness values. An overall value, generated by the four sensor readings, is assigned to each fruit on a scale of 1 to 100, the lower representing the softer fruit. The technology, which can be likened to a hand gently squeezing fruit, has already been successfully applied to a range of fruit types including avocados, apples, kiwifruit, stonefruit and mango. The SIQ-FT is compatible with most major fruit sizing and grading equipment and its software can be used to sort fruit into up to six different firmness bands. The system can segregate fruit of a desired firmness and remove unevenly ripened, soft and bruised produce. The system enables suppliers to provide consistent quality fruit of a specified firmness and helps eliminate the costly rejection of fruit considered too hard or too soft.

perceptions.





The future

Sinclair is dedicated to supporting customers in the commercial application of the SIQ-FT and further developing system technology. Sinclair can assist in the evaluation of quality assurance procedures in order to advise the fresh produce industry on how best to use the SIQ-FT to cut waste, labour costs and increase productivity. Sinclair is confident that the SIQ-FT will continue to prove a revolutionary tool throughout the distribution chain to increase fruit quality and reduce destructive testing.