Ultraviolet technologies for shelf life extension in fresh produce

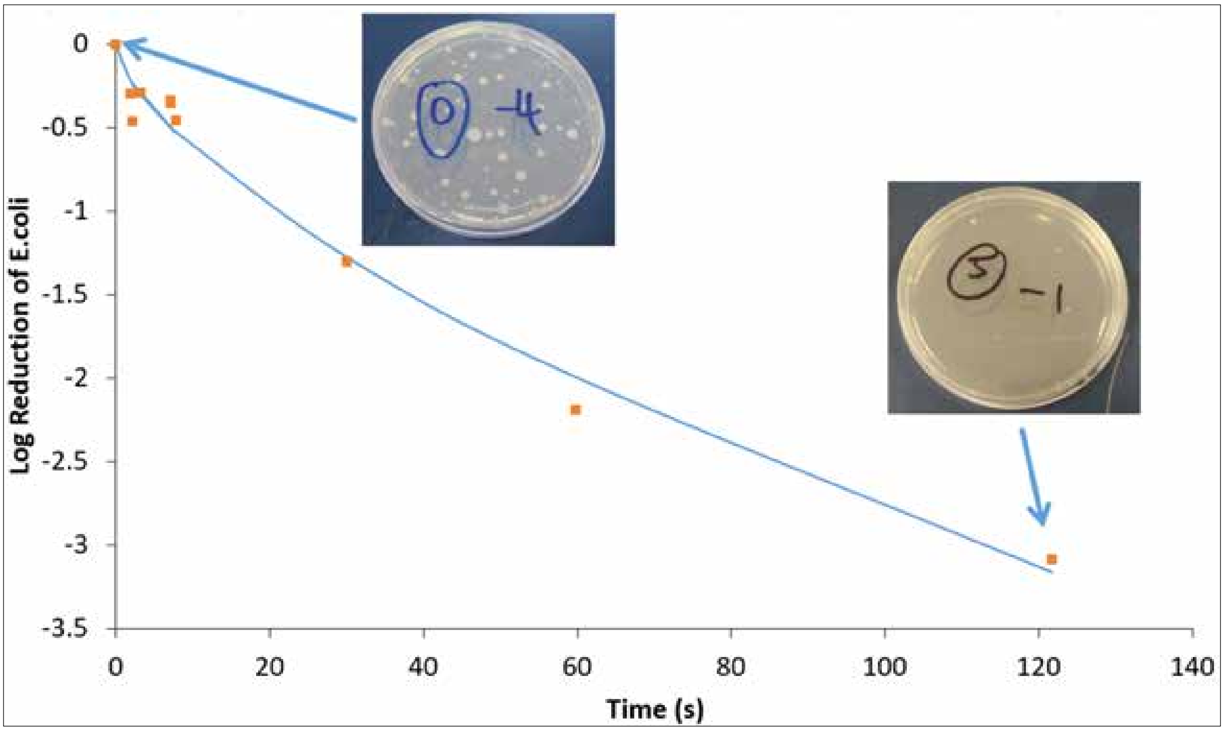
Dr Gonzalo Martinez-Hermosilla and Prof John Bronlund
School of Food and Advanced Technology, Massey University, New Zealand

The research team, left to right, Gonzalo Martinez-Hermosilla and John Bronlund (Massey University) and Lee Huffman (Plant & Food Research) (Absent; Professor Andrew Shilton (Massey University))

Challenges for fresh produce exports

The market for fresh produce is high value and is growing rapidly. Fresh fruit exports from New Zealand have shown sustained growth in recent years, closing in on $10B by 2020. In 2016 alone, fresh fruit export volumes increased 13% with an increase in value of over 30%. Berry fruit exports are still small but doubled to $40M over the past six years and look destined to maintain this growth. Most of the high margin markets for fresh produce are in the northern hemisphere, presenting a geographical barrier for New Zealand exports. Simultaneous growth in both volume and value gives extraordinary advantages to New Zealand. However, sustaining this growth brings additional challenges for an industry needing to ensure product quality throughout the supply chain.

Ultraviolet (UV) technology offers a way to reduce food safety risks and increase produce shelf life. UV treatment has been proven to be harmless to flavour and colour attributes and can improve firmness. It is cost effective, easy to operate and highly scalable. However, the technology is not yet widely used in New Zealand and presents its own challenges. There is room for improvement, particularly for products that are fragile or must be kept dry or are prone to rubbing damage during handling. Faster and continuous treatment systems are required, and ones which treat all the exposed surface without over-treating any one part.



Reduction of E.coli at different exposure time of UV-C

Ultraviolet technology

Ultraviolet light, particularly UV-C (100 – 280 nm), has been widely used in disinfection for many applications as it effectively inactivates bacteria, fungus and viruses. The absorption of UV light by microorganisms damages their nuclear structures, preventing them from replicating. UV-C light has been shown to reduce the concentration of *Escherichia coli O157:H7* and Salmonella spp. present on the surfaces of apples, tomatoes, lettuces, blueberries, strawberries, and raspberries.

UV light also triggers physiological changes that reduce respiration rates and ethylene production in plant material, thus reducing decay and cell degradation of the fresh produce. This can result in longer shelf life and better control of product quality.

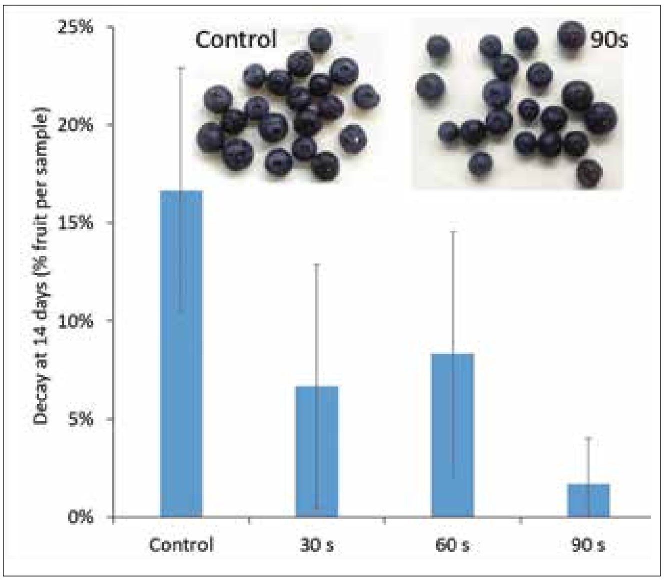
Commercial UV treatments

The mechanisms by which UV light increases shelf life and disinfects fresh produce are well understood and commercial UV systems have been developed for several food applications. Most of these systems are either simple tunnels with the product being conveyed without rolling, or drums that roll product but work in batch mode. Others use fluids to transport products during continuous operation. Some of these deliberately induce turbulence in the fluid motion to cause the pieces of produce being conveyed to expose several sides to the UV source during their passage through the device. These technologies are suitable for products such as meat, frozen fruit, fruit slices and dices, or cooked products. The SurePure® process is now offered for wine, juice and now milk, an opaque fluid. For many other high value fresh products however, these manifestations of UV-C technology might not be adequate solutions.

For pack-house operations, any technology must operate in continuous mode, be safe to operate, be able to treat product at the rate of the grading lines, and be suitable for full integration in the postharvest processing system. Products such as berry fruit can be susceptible to fungal infection, therefore treatments that require liquid media must be avoided. Fragile products must also be handled with the maximum care to avoid bruising, or other physical damage that can itself reduce fruit quality and shelf life.

UV treatment for fragile produce

The FIET UV Technologies project is operated by Massey University and Plant & Food Research. The project seeks to solve these problems in a device targeted at New Zealand use on fragile, high-margin fresh products. The project aims to prototype a commercially viable treatment system using blueberries as the example product. It will illuminate all the fruit surface with UV light evenly, without over-exposure of any segment. This will be achieved by moving the fruit gently through a carefully defined trajectory, to deliver the required UV dosage. The system will operate dry and in continuous mode. Most particularly it will be designed to drop in and operate in existing fruit grading lines. Operation of the technology to ensure even UV exposure will be optimised through mathematical modelling of fruit motion. The approach will ensure the technology can be quickly adapted to optimally treat a wide range of fruit size and shape distributions while minimising handling damage.



Decay at 14 days of storage for fruit treated with different UV-C exposure time

Interior of UV treatment system

Case Study: Fresh blueberries to date and future work

We chose fresh blueberries as the case study for this research because of the increasing global demand and local interest in growing this crop. In the three main regions where blueberries are consumed, North America, Europe and Asia/Pacific, the demand is larger than internal production. Elements of the New Zealand horticultural sector have been systematically taking new initiatives to develop blueberry cultivation. A great example is the joint venture between industry and government (Plant & Food Research) to develop a new blueberry variety that will provide New Zealand with a unique product in the marketplace.

Over this first year of work, we have successfully proven concepts behind the design of the technology. To do this, we manufactured a basic and non-optimised prototype for testing different treatment conditions. Our main progress is summarised as follows:

- The UV light technology reduced water loss and maintained firmness of blueberries during 14 days storage.
- No fruit decay was present on any UV-treated blueberries while fungal contamination was found on control (untreated) samples.
- We were able to find realistic operational conditions, even with the first rough prototype, which did not damage the fruit – minimal cuticular wax was lost from blueberry surface by rubbing against other berries or against machinery.
- A basic model to predict cuticular wax removal after UV treatment has been created. This is a powerful tool to estimate the maximum extent of treatment that can be achieved without affecting fruit quality.
- We are now extending these studies to Rabbiteye blueberries.

In conjunction with Plant & Food Research, we are about to start the construction of a three- dimensional library of blueberry shapes to help with predicting berry motion in a notional treatment device. The second-generation prototype currently under manufacture will let us investigate the detail of fruit motion and better control of UV treatments.

Looking forward – other applications

We believe that this technology is not limited to blueberry applications. The mechanistic nature of the models used for optimisation and design of UV treatments makes possible the estimations of optimum treatment conditions for other products. Examples of further application are small round fresh products, grains, and nuts. Anyone wishing to discuss an application should contact Dr Gonzalo Martinez-Hermosilla at G.Martinez@massey.ac.nz.

FIET
Food Industry Enabling Technologies

Food Industry Enabling Technologies (FIET) is funded by the Ministry for Business, Innovation and Employment and its purpose is to support new process developments that have the potential to add significant value to our national economy. The programme has six partners, Massey University (the host), Riddet Institute, University of Auckland, University of Otago, Plant and Food and AgResearch. Funding is $18m over six years (2015-2021) and targets pre-commercialisation activities. If you are interested in more information, then please contact either Ross Holland (R.Holland1@massey.ac.nz) or Professor Richard Archer, Chief Technologist, (R.H.Archer@massey.ac.nz).