FIET Project 13: UV technologies for shelf life extension in fresh produce

Authors: Professor John Bronlund[1], Dr Syahmeer How[1], Dr Mario Alayon-Marichal[2], Ms Shirley Miller[3], and Dr Gonzalo Martinez[1*]

[1]Massey University, Palmerston North; [1*]formerly Massey University, Palmerston North; [2]The New Zealand Institute for Plant and Food Research Limited (Plant & Food Research), Palmerston North; [3]PlantWise Ltd, Tauranga

Dr Gonzalo Martinez, (formerly Massey University)

Professor John Bronlund

Dr Syahmeer How (How)

Dr Mario Alayon-Marichal, Plant and Food Research

Shirley Miller, PlantWise Ltd

Ultraviolet light can extend shelf life in fresh produce such as berries and grapes. It acts in two ways: microbial inactivation of spoilage organisms and initiating stress responses that result in increased antioxidant production. Commercial UV treatment is used in water treatment and is gaining traction in less transparent fluids such as juices, wastewater and wine. Its successful application in solid produce such as berries or cherries presents new challenges as it requires even exposure to the whole fruit surface to be effective.

FIET Project 13 focuses on the control of the movement of berries in processing lines to achieve even UV exposure for shelf life extension.

Team update

This project was initiated by Dr Gonzalo Martinez, who led the research, design and testing of prototype treatment systems, interactions with industry partners and the development of mathematical models for the movement and UV exposure of berries during treatment. In August 2020 Gonzalo left Massey for Europe. We truly appreciate all the hard work and effort he put into the research and although he was keen to see the project through to completion, other opportunities intervened. Nothing is ever a problem to Gonzalo and he is a master at picking up new modelling approaches and applying them to new applications. The wider Massey engineering, postharvest and packaging research teams will miss his significant contributions. We wish Gonzalo the best for his future endeavours and have no doubt he will have a brilliant research career.

John Bronlund has picked up the mantle to lead the project through to completion by July 2021. Syahmeer How has been appointed to complete the design, implementation and testing of the final prototype for the project. How (as he is known) has recently submitted his Riddet Institute funded PhD in bioprocess engineering and brings experimental and modelling skills to the project. How has already got up to speed on shelf life testing, UV treatments and spoilage organism microbiological assays.

Dr Mario Alayon-Marichal at Plant and Food Research is investigating how UV and other novel treatments, such as ozone, influence fruit polyphenol and ascorbic acid levels. These compounds are important in extending the product shelf life and provide nutritional benefits. He found that the ascorbic acid is stable during ozone treatment of blueberries and polyphenols, especially anthocyanins, increased significantly during storage after treatment.

Results from preliminary shelf life extension experiments using ozone, by Ann Gie Teo from the Singapore Food Technology class in her final year research project, suggest ozone is a viable technology and worthy of future research.

Shirley Miller, a horticultural consultant at Plantwise, is another key member of the team. She provides industry insights and links the project to growers, packers and marketers of berries. Through Shirley, we have built strong partnerships with Berry Co, Miro LP, Bella Berries, Berry Packers Ltd (BPL) and Apata Group Ltd.

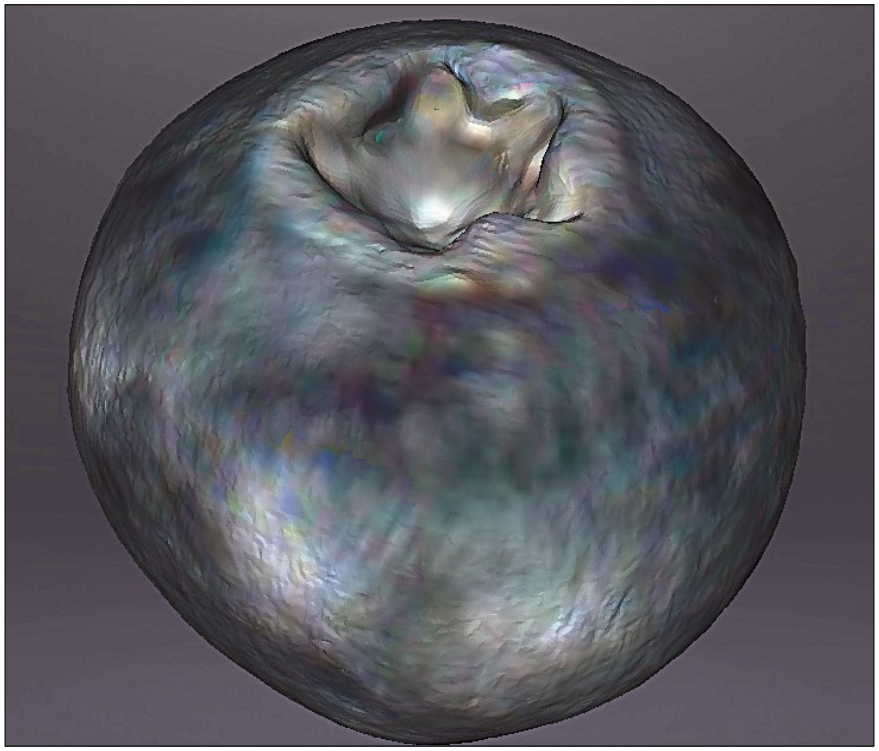


Figure 1. An example of a 3D scanned blueberry from the shape library

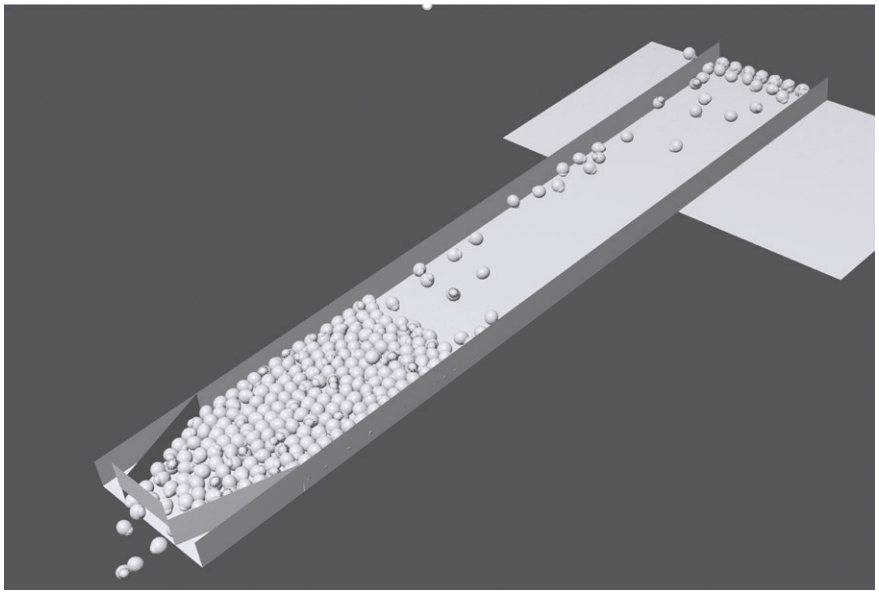


Figure 2. Prediction of berry motion on an inclined surface used opensource simulation software, Blender

Botrytis cinerea – A key industry challenge

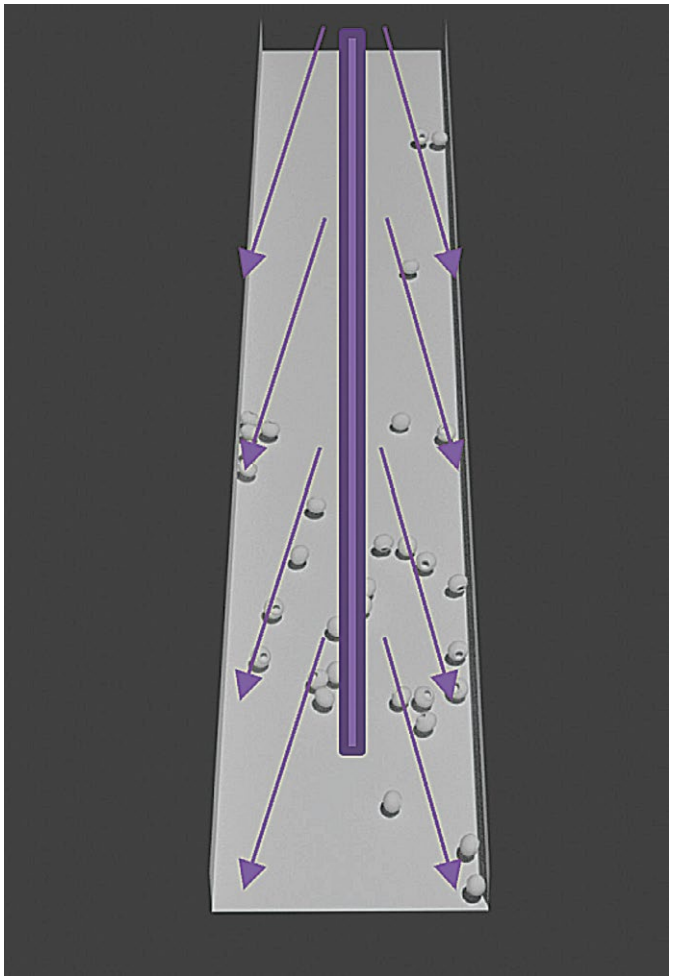
The 2019-2020 blueberry seasons have provided significant challenges for industry from the spoilage fungus *Botrytis cinerea* or grey mould. The introduction of early season fruiting varieties combined with favourable climatic conditions over flowering and fruit development have led to above normal incidence of this organism. This has contributed to increased issues with spoilage throughout the supply chain, and reduced shelf life. Together with continual improvements to on-orchard management, harvesting and postharvest handing practises, treatments such as UV or ozone can contribute to mitigation of this disease. UV has been shown to be effective against *Botrytis* in fresh blueberries in the published literature and in lab-based trials completed by our research team.

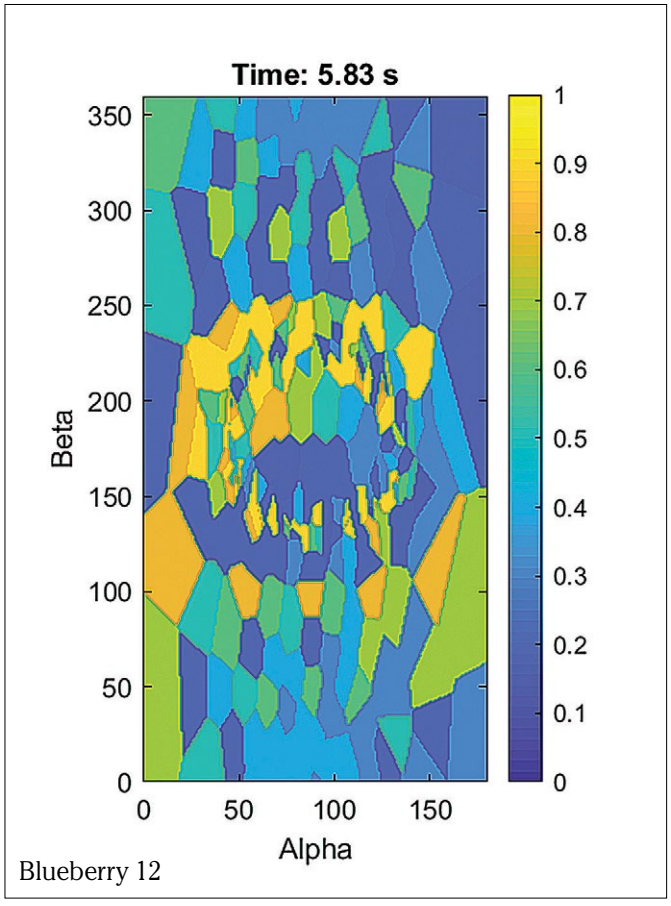
Modelling berry movement and UV exposure

The key to effective UV treatment is exposing the entire fruit surface to light. Mathematical modelling techniques can aid the design of systems to achieve this. Gonzalo, with generous help from Berry Co, has built a database of 3D scanned fruit from different berry varieties (Figure 1). Early season fruit tend to be larger and flatter, while fruit may be smaller and more spherical later in the season. This variance means that the surface area to be treated and the rolling behaviour, differ throughout the year. A shape library allows mathematical modelling of how the systems can be designed to provide the optimum quantity and homogeneity of exposure (Figure 2).

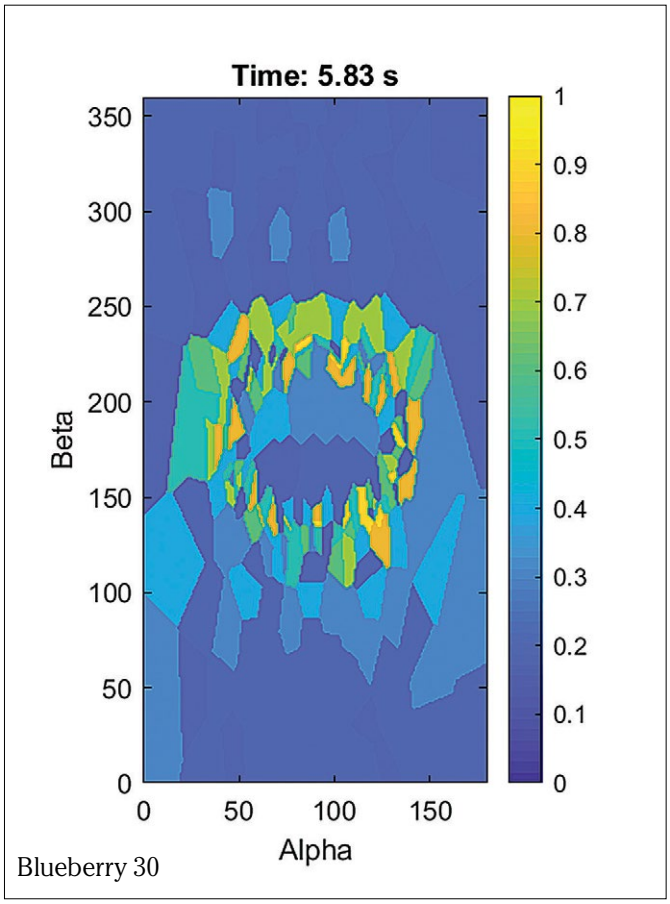
"Blender", an opensource physics engine, was used to simulate the motion of the berries in each prototype. This software can predict the position and orientation of populations of berries rolling in the system. In this way the effect of berry geometry on movement can be evaluated to ensure we design the process to maximise efficacy for fruit harvested throughout the season.

From the predicted berry history of orientation and position of the fruit relative to the UV source, the UV dose each berry receives can be estimated. Figure 3 shows differences in UV exposure that two different berries receive in the same treatment. By running large numbers of simulations, the average surface treatments can be assessed as part of the design process.

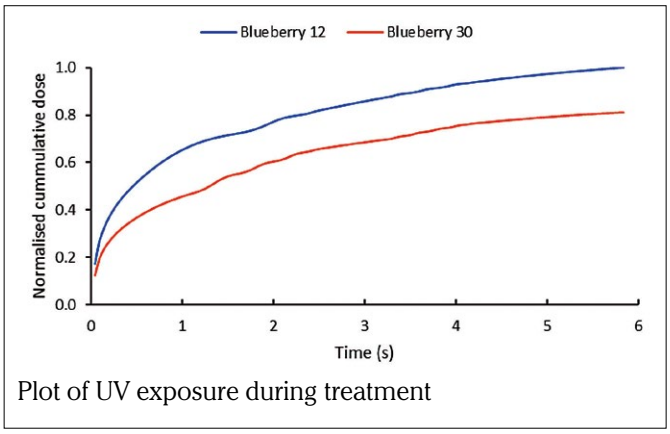




Blueberry 12



Blueberry 30



Plot of UV exposure during treatment

This series of images shows how the "Blender" open source physics engine can simulate the exposure of the berries to UV in prototype irradiation units. Top left shows that berries roll on different tracks in under an axially mounted lamp. Bottom right shows the overall exposure collected by two berries, which took different tracks during a ~6 second exposure. The coloured panels represent 2-D maps of the surfaces of the same two berries showing that some patches accumulate higher exposure than others during ~6 seconds of rolling

Quotes from our industry partners

Shirley Miller, PlantWise consultant, *works collaboratively with BerryCo to continually improve the quality of their produce.*

"We believe that the professionalism and experience that the Massey team bring to this project will help us to reach our customers with better quality fruit. If this technology improves our reject rates in the packhouse, everybody wins".

BerryCo's Technical Manager, Alan McLean

"It is a really worthwhile project focussing on an area of genuine need."

Michael Egleton, licensee and grower of MBO blueberries, *speaking on behalf of Berry Packers Limited.*

"At a high level, if this is able to improve our in-market rejections, then I suggest that a discussion with the operational team is appropriate."

Prototype development

Early rotating prototypes ensured continuous rolling of the fruit and even UV exposure. However, continuous rolling comes at the expense of potential damage and rubbing off the desirable waxy bloom from the fruit surface. As well as consumers seeing bloom as a sign of quality, the waxy layer helps protect the fruit from moisture loss during transport and storage. This potential negative impact, plus the need to integrate more directly into existing grading and packing infrastructure, has led to the development of simpler systems that exploit the movement that berries experience during grading and filling operations. The latest prototype has allowed the testing of different strategies for light source placement and berry exposure on *Botrytis* inactivation and fruit shelf life in a way that translates directly to commercial packing lines.

From a residence time study at the Apata packing facility in Eastern Bay of Plenty an implementation plan and a series of key steps have been developed to demonstrate UV treatment at small commercial scale. We now are in the process of design and manufacture of a final prototype UV treatment system that is integrated with a punnet filling machine provided by Berry Packers BPL. After some preliminary trials on this system at the end of the 2020-21 season, the device will be ready for BPL to carry out their own trials in the new season.

We highly value the open collaboration we have with our industrial partners, BerryCo, BPL, Miro, Bella Berries, PlantWise, Apata and the growers that supply fruit and insights that guide the research. Through these interactions we have begun to build new research programmes in the production, processing and packaging of berry fruit.

Other fruit crops such as cherries and kiwiberries may also benefit from UV treatment and can be tested using the developed technology.

Coming to you soon

Visit FIET at Central Districts Fieldays, Feilding, Manawatu, 18 - 20 March 2021 and FoodTech PackTech, ASB Showgrounds, Auckland, 13 - 15 April 2021.

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 research partner organisations, Massey University (the host), Riddet Institute, University of Auckland, University of Otago, Plant and Food and AgResearch. Funding is $16.65m over six years (2015-2021) and targets pre-commercialisation activities. If you are interested in more information, then please contact either Dr Ross Holland (R.Holland1@massey.ac.nz) or Professor Richard Archer, Chief Technologist, (R.H.Archer@massey.ac.nz).