SEGMENT

MARCH 2021
ISSUE 2

Food. Environment. Society.

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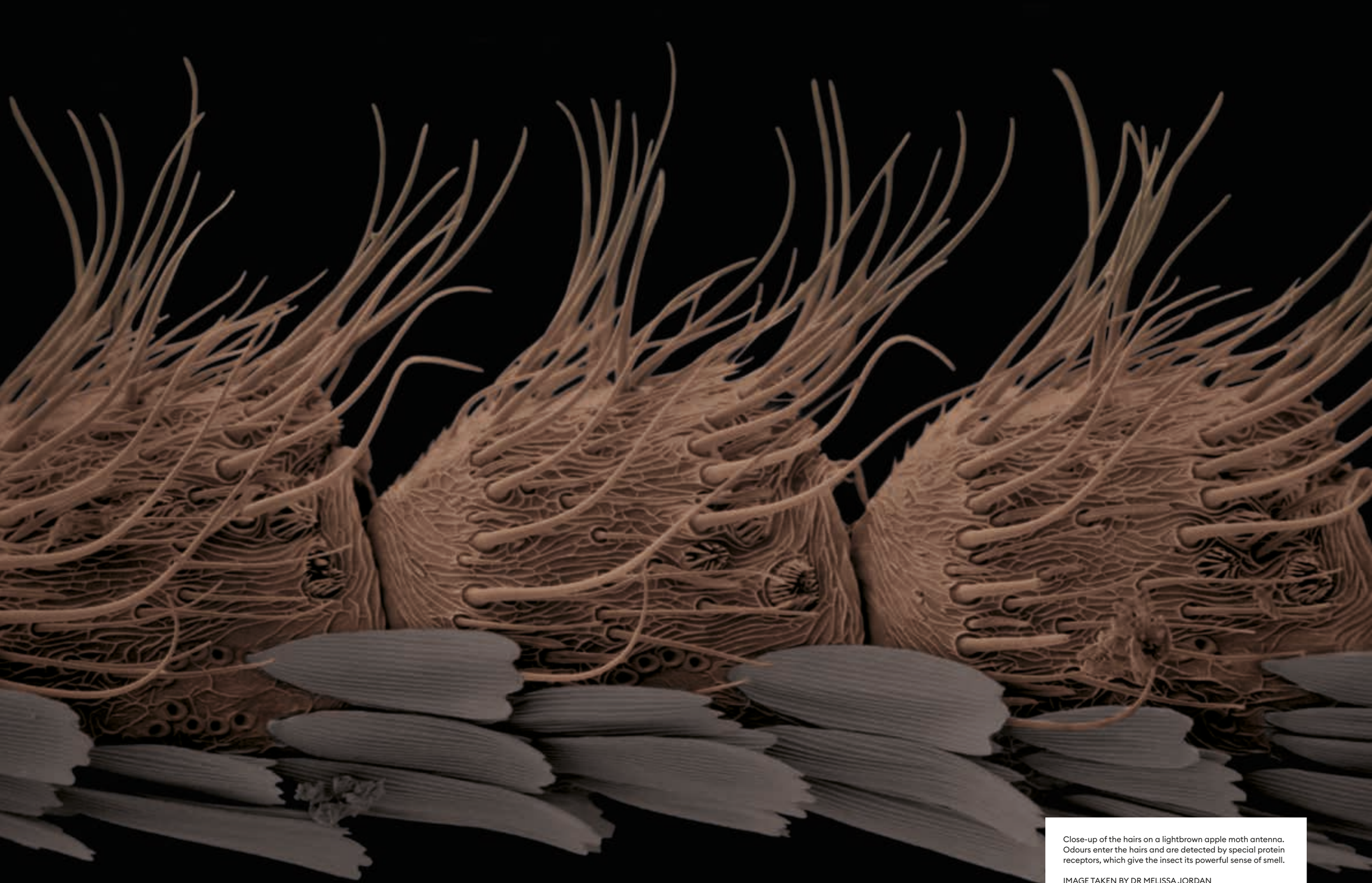

Close-up of the hairs on a lightbrown apple moth antenna. Odours enter the hairs and are detected by special protein receptors, which give the insect its powerful sense of smell.

IMAGE TAKEN BY DR MELISSA JORDAN
Team Leader, Molecular Sensing

PUBLISHER
Segment is published by Plant & Food Research. It can be found online at www.segmentmag.nz
Published March 2021
120 Mount Albert Road
Mount Albert
Sandringham 1025
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PRINTING
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FSC mixed logo here

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Plant & Food Research
Rangahau Ahumāra Kai

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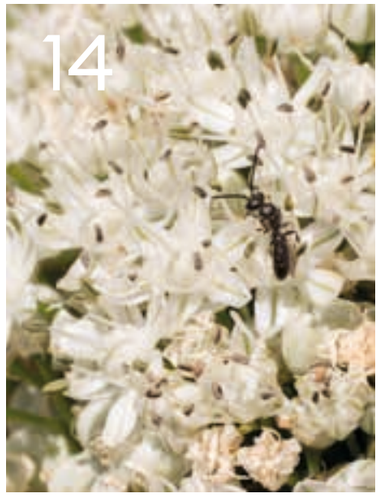

INSIDE SLICE

A look inside Plant & Food Research

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OPINION

REGULARS

Welcome to Issue 2 of Segment magazine.

Inside, we share insights into the issues, challenges and opportunities that inform our science and influence the global food sector.

The world of food production, including the environment it operates in and society's relationship with food, is continually evolving. The COVID-19 pandemic has only accelerated this, highlighting issues and opportunities for the food industry. In Aotearoa New Zealand, our strong export sector and reputation for high quality, safe food has held us in good stead.

In this issue of Segment, Donna Chisholm looks at the psychology and science of taste and how this influences the creation of new food products. Damian Christie takes a look at how science is innovating new ways to turn by-products into premium products and Matt Philp explores the under-appreciated role played by New Zealand's native insects. We also hero the humble New Zealand blackcurrant and share some striking microscopic images.

I really hope you enjoy reading our magazine and sharing a 'segment' of our world.

David Hughes.

David Hughes
CEO Plant & Food Research

Soap bubble pollination

While blowing bubbles with his son, Professor Eijiro Miyako, was inspired to use bubbles as a low-cost and gentle way to deliver pollens to plants. Miyako and his research partner at the Japan Advanced Institute of Science and Technology developed a pollination system that involves mounting a bubble-maker on a drone. Using a commercially-available bubble solution, they added pollen-protecting ingredients and a polymer for sturdiness. The researchers tested the system on three pear trees. Ninety-five percent of the 50 pollinated blossoms on each tree bore fruit, similar to trees pollinated by hand with a standard pollen brush. About 58% of flowers on another set of trees pollinated by insects and wind bore fruit.

The world's smelliest phone charger

Durian and jackfruit often polarise people, thanks to their pungent smell. But scientists are looking at how to harness the smell to make super capacitors that could rapidly charge devices. A research team at the University of Sydney have developed an engineering method that uses heating and freeze-drying to turn durian and jackfruit waste portions into stable carbon aerogels. The carbon aerogels make great super-capacitors and can store large amounts of energy quickly within a small battery-sized device. The novel capacitors can supply energy to charge gadgets such as smartphones, tablets and laptops more efficiently than conventional super-capacitors.

Fish eggs can hatch and survive being eaten by ducks

Water birds may unintentionally disperse fish, including invasive species, in isolated water regions through their poop. Evolutionary biologists, led by the Centre for Ecological Research in Debrecen, Hungary, fed 8,000 eggs from two carp species (considered invasive in many countries) to eight mallard ducks. Eighteen eggs, about 0.2% of the ingested eggs, survived gut passage. Some contained live embryos and a few eggs even hatched. Most of the viable eggs were pooped out within an hour of being eaten, but migratory ducks could travel great distances before excreting those eggs – meaning they could still play a significant role in long-distance dispersal of invasive carp.

Taste gene makes certain people dislike vegetables

Genetics may explain why some people find certain vegetables bitter. Every human has two copies of a taste gene called TAS2R38. People who inherit two copies of the variant called AVI aren't sensitive to bitter tastes from certain chemicals, but those with one copy of AVI and another called PAV perceive the bitter tastes of these chemicals. Individuals with two copies of PAV, the "super-tasters", find the same foods exceptionally bitter. These people are likely to find broccoli, Brussels sprouts and cabbage unpleasantly bitter and also dislike dark chocolate, coffee and sometimes beer. The research team, led by the University of Kentucky School of Medicine in Lexington, hopes to use this genetic information to identify ways to help super-tasters eat more vegetables.

Mānuka: first genome sequence for a New Zealand native plant species

Scientists at Plant & Food Research have for the first time sequenced a New Zealand native plant species. The plant is a mānuka variety called 'Crimson Glory'. A large proportion of the mānuka genome was found to contain bacterial and fungal sequences, indicating the presence of a microbiome. Mānuka is a widespread indigenous New Zealand shrub and is a taonga (treasure) for Māori. Mānuka honey is a commercial product valued for its antibacterial properties due to methylglyoxal (MGO), which is formed from the nectar-derived sugar dihydroxyacetone (DHA). The amount of DHA varies greatly among individual and regional populations. Genomic resources could aid breeders and enable researchers to understand key traits like DHA accumulation.

How to make fried rice, according to science

Fried rice is one of the world's most popular takeaway dishes. It's traditionally stir-fried in a round-bottom wok on extremely high heat with frequent tossing, which often puts strain on the chef's body. Georgia Institute of Technology physicists analysed videos of five professional chefs and their stir-frying kinematics. The wok toss has a period of 0.3 seconds and involves two directions of movement – translation (sliding the rice along the wok) and rotation (throwing the rice into the air). The physicists identified an optimal regime for making fried rice and ways that wok tossing may be improved. The mathematical models could inspire the production of robotics and exoskeletons to reduce muscle strain injury among professional chefs.

Spinning gold

From by-product to premium product

Hoki collagen being spun into nanofibres.

Damian Christie looks at the business of food utilisation and how companies are using science to improve sustainability and enhance value for by-products.

Hundreds of kilometres off the coast of New Zealand, a hoki boat is hauling up its latest catch. Several times a day, for six weeks or more at a time, the trawling vessel pulls tonnes of hoki up from the cold, deep waters.

On board seafood company Sanford's trawlers, automated machines precisely fillet the fish as they pass along the conveyer belt. The fillets are packed by hand and snap frozen. But these fillets only make up around 40% of the fishs' weight. For decades, the remaining parts of the hoki, including the skin off the fillets, have been rendered into fish meal and oil, both processes also done on board.

Fish meal and oil are relatively low value commodities but they have ensured that some use is made of every part of the fish. However, these days hoki skins are separated from the by-products and begin a journey that will see them transformed into a range of premium products, including cosmetics sold in high end department stores globally. Gram for gram, this hoki collagen's value far exceeds the price of the fillet.

"Calling it 'waste' puts us into a mindset that this material has no value, or a negative value", says Lynne Scanlen, Plant & Food Research's Manager of Strategic Projects. "In some cases it mightn't be an economic value but it still might have value in terms of environment and social outcomes, such as employment."

The drive to add value is about matching high quality raw materials with demand in a market. "The piece in the middle", says Andrew Stanley, Sanford's GM of Innovation, is where the science comes in. "This is where we have exploration and discussion with Plant & Food Research and other companies about what technology is available, what knowledge is there and what products can be created."

Sanford's commitment to maximising the value from its seafood resource has seen the business invest $20 million in a new high-tech marine extracts facility in Blenheim, to be opened next year. The facility will continue work with products like hoki and other fish skins, as well as green-lipped mussel extracts and, in the future, seaweed products.

"I've seen a lot of biomass underutilised and I'm driven to find homes for that," says Stanley "We know we have a great set of resources at our fingertips, we're matching that with quality science from our science providers to create exceptional opportunities."

Plant & Food Research's Science Group Leader for

Marine Products Research, Dr Susan Marshall, has been working with Sanford as well as other seafood companies to develop high-value products from by-products previously broken down for fish meal or oil. She says the first challenge is to understand exactly what molecules the by-products contain, something that has long been overlooked with our focus on the fillet. Each species has its own particular features. For example, the collagen extracted from the deep water hoki has a lower melting temperature than other forms of collagen, which is part of the reason that skincare products based on hoki collagen absorb into the skin deeper and faster than other collagen products.

While the fish processing industry has long found at least some use for its by-products, even if simply as fish meal, other industries are left with a waste problem on their hands. Heilala Vanilla is a Tauranga-based producer of vanilla extracts, such as powders, syrups and pastes. The company has vanilla plantations in Tonga, and is committed to sustainability and humanitarian outcomes as part of its mission.

When Heilala began, it produced only the extract from its vanilla pods. In 2008, it began also using the vanilla seeds, to produce a vanilla paste. As vanilla prices began to rise – to more than the price of silver – Garth Boggiss, Heilala's co-founder and head of R&D, says he started to look at whether the company could be getting more out of its raw materials.

The first step for Heilala was to determine whether there were any inefficiencies in its existing business, but on investigation found it was already extracting 98% of the vanilla from the pods. The focus turned to what else might be left over in the discarded husks, and a series of full spectrum chemical analyses with Plant & Food Research scientists turned up an unusual lipid group that existing research shows has bioactive uses in skincare.

Commercially, the bioactive compound is worth around $3000 per kilogram as a raw ingredient – far more than the lucractive vanilla extract itself. But Boggis says one of the tricky parts of creating a business from by-products is understanding the size of your supply.

"The issue is that we can only generate it from our waste streams, so when we were trying to find the right partner they had to be the right size as well – if they were like 'well we need 10 times the product' then we couldn't supply it. If you just took fresh vanilla beans and your only use was to create the bioactive compound then it wouldn't be viable."

Trying to find a commercial partner the right size has led Heilala to try creating its own skincare product. After several years and a few different research projects, Boggiss says, "it's a big journey."

Like Heilala's vanilla pod research, each new seafood project requires a new fundamental understanding of what that particular species contains. Marshall says the only information for many New Zealand fish species was produced by one researcher back in the 1980s, and only at a very basic level. To gain full value from the whole fish, that understanding must be much deeper.

Marshall believes that if an entire fish is utilised to its full potential, the value could be five times what it is currently worth as fillet and fish meal. The focus could shift entirely, where some fish species are farmed for everything but their fillets.

"We often hear about the circular green economy, but for us it's also about the circular blue economy," Marshall says. "My drive at the moment is to try and apply that idea to aquaculture, where perhaps we grow some species not for fillet, but from the outset focus on nutraceuticals or biomaterials instead. It's trying to look at things in a different way, rather than fish just as something you eat, to seeing it as a complex raw material with multiple potential uses."

While there are certainly economic opportunities from by-products, not all projects are about the bottom line. Another project with Motueka-based Golden Bay Fruit has been looking at what to do with apples and kiwifruit that aren't up to its high export standards – about 15% of total production. The company has just finished a state-of-the-art packing facility and with a local juice producer leaving the region the challenge provided an opportunity to look at new by-product alternatives.

"We weren't really looking at it to make money out of it," says Heath Wilkins, the company's CEO. "It was more about a by-product that we had, can we turn it into a useful story that's potentially fuelling our tractors or farm equipment. As long as it covered its costs that's what we're looking for."

Commercially, the bioactive compound is worth around $3000 per kilogram as a raw ingredient — far more than the lucractive vanilla extract itself.

Biodegradable packaging is another by-product use that will become more important in the future. There are already companies working in this sphere, such as Auckland-based Earthpac, which extracts starch from water as a by-product of making french fries and turns it into a range of compostable products such as cups, plates, cutlery and napkins. Mushroom stalks are also being looked at by growers as a raw ingredient in a sustainable alternative to styrofoam packaging.

"It's worth thinking about by-product utilisation as a pyramid," says Scanlen. At the bottom, it's low value products using large masses of material – uses like energy from methane and ethanol. Further up are soil conditioners, compost and fertilisers, then biomaterials, animal food, human food – and at the top, high-value extracts such as nutraceuticals or even pharmaceuticals".

With the impacts of climate change and overpopulation putting more pressure on our natural resources and the ability to create them, reducing waste both in production as well as in our own homes is going to be vital. Developing higher-value and premium products from by-products is going to be even more important in the future than it is today. As Scanlen puts it simply, "We're going to have to get a whole lot better at utilising everything we grow".

Collagen extracted from the deep water hoki has a lower melting temperature than other forms of collagen, which is part of the reason that skincare products based on hoki collagen absorb into the skin deeper and faster than other collagen products.

Processing hoki skins to develop high value, premium products.

The science & psychology of taste

Donna Chisholm looks at what's behind the development of novel food products and what psychology, sensory and consumer science can tell us about balancing novelty, popularity and value in new products.

Within hours of Bluebird® announcing that its new Kiwi Favourites™ chips range featured a lamington flavour, social media erupted in collective disgust. The chocolate and coconut-coated cakes our mums used to make were fine for afternoon tea, but potato chips they were not. The kindest assessment on Twitter, after "WTAF?" was that lamington crisps were an abomination.

The day after the launch in late July, TV1 Breakfast host John Campbell proclaimed lamington chips were, "staggeringly bad. You'd have to be really stoned to enjoy that chip." That night, Seven Sharp sent co-host Jeremy Wells to interview staff at the Wiri factory that spawned this dietary demon. In the Bluebird boardroom, meanwhile, there were probably high-fives all round. One bag of chips? $2.20. Five minutes' free advertising on primetime television? Priceless.

The new flavour, one of four which included paua fritters, cheese and onion toastie, and Sunday roast, was least surprising to consumer research experts who recognised the scientific method in Bluebird's apparent madness. Their research suggests the combination of attention-grabbing weirdness and the comfort of tradition can be a winning formula.

"The chips – and the timing of them – are really interesting given the whole COVID-19 experience," says Plant & Food Research psychologist Dr Denise Conroy. "This is very much a nostalgia thing but it is not just about our childhood – it is very New Zealand. We have always seen that in categories that don't cost a lot of money, people do novelty-seek. It's not a great deal of money to invest so if we're disappointed it's not as if we've bought a $75,000 car and we're kicking ourselves."

"We'll start to see many more New Zealand products coming through because of COVID-19. We are cut off at the moment, we are on our own in the world and we've done really well. There's a health halo around New Zealand food anyway in terms of our fresh fruit, vegetables, meat and fish, but that's just increased hugely because of our track record with COVID-19. This is a fantastic story and we should be exploiting it to our absolute advantage."

Conroy herself is not that adventurous when it comes to new flavours, but says she'd consider serving them as a novelty, to experiment with friends. That's just the market the manufacturers are likely to be aiming for, according to Dr Sara Jaeger, Plant & Food Research's Team Leader of Sensory and Consumer Science. "You see limited-time offers of weird and wacky flavour combinations in all sorts of product categories now. It's an almost global phenomenon and it also has something to do with social media, where people can take pictures and say, 'Look what I ate; isn't that funny and exciting?' There is a clear experiential element to it."

Jaeger, internationally renowned for her work in sensory food science, has teamed up with another of the world's foremost researchers, Massachusetts-based Dr Armand Cardello, to examine uniqueness in food products, to understand consumers' sensory and emotional responses.

One paper they co-authored, published in Food Quality and Preference in 2016, focused on the "explosion" of craft beers, a category that varies greatly in style, quality, ingredients, sensory attributes and brand images. They found that consumers generally regarded the most familiar or traditional beers as "ordinary", "boring" and "simple". Although beers described as appealing were found in both the novel and familiar categories, familiar products were deemed more appropriate for "everyday" situations, while novel beers were seen as more fit for special occasions. The more "ordinary" beers also attracted passive emotional responses, such as "dull/bored/uninspired" but the novelty brews evoked more active emotions, and were more likely to be described as intriguing and complex.

"You are trying to have a product that is liked, but also elicits some excitement," says Jaeger. "Emotional activation can also be negative and there can be disgust-type responses. For example, oysters can be really polarising, so you are trying to find a product that offers excitement in a positive way while at the same time not being so niche that you are only trying it once for fun." Some fast-moving consumer goods, such as chips, are probably only ever intended as a short-term gimmick, particularly when they don't cost a fortune to produce and change out flavours, she says.

> "This is very much a nostalgia thing but it is not just about our childhood — it is very New Zealand.

Jaeger and Cardello have developed a 31-item Food and Beverage Need for Uniqueness (FBNU) scale to measure consumers' predilection for unique food and drink and to better understand their behaviour. In a paper on the scale published last year, they said that individuals scoring high on the FBNU scale perceived less difference between novelty foods and drinks and familiar ones, expected to like them more, had more positive emotions toward them, were more willing to eat/drink them, and saw them as more appropriate to use in a wide variety of consumption situations.

Plant & Food Research's work with producers and manufacturers helps them to move from being very "liking-focused" into broader notions of connecting with the consumer on multiple levels. The importance of recognising a consumer's emotional response to food, and the crucial role of the social setting in which it's consumed, has long been recognised, Jaeger says.

"Where possibly the change has been is that we are now trying explicitly to connect that emotional aspect directly into the food products and their characteristics."

While consumer "liking" is critical, it is not the only predictor of how successful a product will be. "We need to better understand consumers' overall experience. We're not saying you can ignore what a product tastes like, because if it doesn't taste good the chance it would be consumed repeatedly is very low, but there are products that taste nice that are not particularly successful, so what else is it that we need to understand about people's experience of these products that we can tap into? That's where the emotional space has some traction."

Dr John Prescott – former director of the University of Otago's Sensory Science Research Centre and now a British-based taste consultant – notes in his book *Taste Matters: Why we like the food we do* that some top chefs, such as the innovative Heston Blumenthal of Michelin-starred British restaurant The Fat Duck, capitalise on "a multisensory immersion in sights, sounds, odours, textures and tastes, with contributions from memories and emotions. One clear aim is hedonic, but it is at least partly pleasure based in memory, the evoking of warm feelings of nostalgia."

Even the description of a dish can alter a consumer's experience of it. In one study Prescott quotes, participants ate an identical dish but some were told it was cold smoked salmon mousse, others that it was smoked salmon ice cream. Those who thought they were eating mousse were markedly more positive about the dish – fish-flavoured ice cream, however, was more difficult to make sense of. In the book's foreword, Blumenthal writes that discussions with scientists such as Prescott have had a powerful influence on the direction his cooking has taken.

Weird flavour combinations, such as bacon and egg ice cream offered at The Fat Duck, seem to excite novelty-seeking consumers, says Jaeger. However, her research indicates there's a small but not insignificant group – around 20–25% of people – who are moderately to severely food neophobic, meaning they'll try to avoid unfamiliar foods. Although food neophobia typically peaks in toddlers, there are genetic components: identical twins are much more likely to have similar levels of neophobia than non-identical twins. Plant & Food Research can use this information to measure where people sit on that psychological construct and thus better understand their food choices.

The popularity of flavours and flavour combinations is tracked on international databases and many of the innovations that apparently come out of left field, or are marketed as uniquely Kiwi, in fact are not. For example, lamington-flavoured crisps were launched across the ditch in January 2020 by Smith's, which hyped them as quintessentially Australian, with the taglines, "Strewth what a Beaut" and "Fair dinkum – it's lamington".

The powerful influence of branding and description on how consumers experience a product is apparent from the popularity of Whittaker's chocolates that trade on old Kiwi favourites such as Jelly Tip ice cream and L&P (Lemon & Paeroa) soft drink. Dr Roger Harker, Plant & Food Research's Science Group Leader of Consumer and Product Insights, says consumers in taste tests are good at describing sweetness, bitterness, acidity and texture but struggle to find words for particular flavours.

Even the description of a dish can alter a consumer's experience of it... some were told it was cold smoked salmon mouse, others that it was smoked salmon ice cream. Those who thought they were eating mousse were markedly more positive about the dish.

"I'm sure a Jelly Tip ice cream is a completely different sensory experience to the chocolate, but because they've given it a name, the consumer is looking for something that prompts their mind to recognise it, such as the colour palette and jelly texture rather than the flavour. You have to have something in the product to trigger that memory," says Harker.

Until recently, there was no way of measuring uniqueness or understanding its value. Now scientists use a uniqueness curve to plot novelty against popularity and value. "It's easy to make something unique that nobody likes, and it's probably really easy to make something that's the same as everyone else's, but you don't gain much value," says Harker. "What you are trying to do is be at the top of that curve, for maximum uniqueness for maximum value or liking."

Will lamington chips top the curve? Not if the Australian experience is anything to go by. On Smith's Chips Facebook page, they've not rated a mention since their launch, and have been superseded since by a string of new flavours. Teriyaki chicken or sizzling beef chips anyone?

We'll start to see many more New Zealand products coming through because of COVID-19.

Dr Denise Conroy, Team Leader Stakeholder & Consumer Intelligence.

FEATURE

Unsung heroes

Matt Philp looks at the hugely important but underappreciated role played by native insects in New Zealand's ecosystems and agriculture.

Lasioglossum bee, the smallest of the native bees.

Their numbers are legion, they're crucial players in healthy ecosystems and, according to some accounts, they're on the brink of a calamity that will change their world and ours, yet insects fail to pierce our consciousness in the way of more charismatic fauna.

"Insects are hugely underappreciated", laments University of Auckland ecologist Professor Jacqueline Beggs.

They're also a puzzle that's still only partly understood – even by experts who have devoted careers to them. New Zealand, for example, is thought to have 20,000 insect species; less than half have been described and named.

But don't mistake anonymity for irrelevance.

"Insects are at the heart of so many critical ecosystem processes", Beggs says. "They're the herbivores who are eating plants and helping to recycle nutrients. They're doing the pollination and seed dispersal. They play a critical role in the decomposition of dead materials both plant and animal, and are therefore crucial to nutrient cycling and the building up of soils. They play an important role in predation and parasitism, helping to keep down pests (of course, sometimes they *are* the pests) and as food sources for different taxa. And they're fungivores, feeding on fungi and helping their dispersal and nutrient cycling. There's almost no ecosystem process that doesn't involve insects."

Who are these tiny unsung heroes? How can we ensure they thrive? And how do we make the most of their talents?

Plant & Food Research's Dr David Pattemore says that New Zealand's native pollinators are distinctive. "In most of the world, you have bees and butterflies being really important groups of pollinators. But here in New Zealand we have flies and a great diversity of moths and beetles, and we find in native systems that it is often these other insects that are visiting native flowers."

Because of these differences, insect decline is likely to have unique, unpredictable impacts on the functioning of New Zealand's ecosystems.

When it comes to agriculture, "We're developing a pretty strong picture around the role of native species and we are finding flies have been especially under-appreciated," Pattemore adds. "We've documented quite a number of these wild species, particularly flies and native bees, which turn up again and again in different crops in different regions."

That said, there is a pressing need to promote greater diversity of insects on our farms. If Northern Hemisphere reports of alarming declines in populations of bees and other insects are accurate, there's no reason to think this country won't be at risk. Spreading the pollination workload would cushion the impact.

"We know that pollinator diversity improves crop yields", says Plant & Food Research scientist, Dr Brad Howlett. "Honey bees are not always the best crop pollinators, so fostering diversity increases your chances of having the most efficient pollinators in your crop, and these insects may be active when honey bees are not. For example, bumble bees are better pollinators of clover than honey bees, plus they are active earlier and later in the day than honey bees are."

Howlett and colleagues are involved in several initiatives to promote on-farm insect diversity. One area of focus is on providing organic material to support insect larvae and pupae. Another is native plantings (see next page).

Flexibility is key, explains Howlett. "If a farmer is growing a complex mix of crops, for example, we'd look at what sort of things need to be encouraged on that farm. It might be native plantings; it might be providing resources for larvae that target specific species. So it's about following the insects, knowing which ones to target and then helping the farmer to manage those practically".

> "... fostering diversity increases your chances of having the most efficient pollinators in your crop.

©Steve Kerr (CC BY)

Flies such as the Blue hover fly (*Helophilus hochstetteri*) are important pollinators in New Zealand.

Designing on-farm native habitats — enhancing insect diversity for crop pollination and protection

"Creating more productive, resilient farms and conserving New Zealand's insect diversity are not incompatible goals," says Plant & Food Research's Biodiversity and Pollination Scientist Dr Melanie Davidson.

On the Canterbury Plains, an area that has suffered a notable loss of native habitat and animal diversity, Davidson and colleague Dr Brad Howlett believe it is possible both to boost crop production and simultaneously enhance New Zealand's insect diversity.

"The enormous benefits that New Zealand's insect fauna can play in pollinating crops and controlling insect pests has not been properly considered", says Davidson. "Instead, we've tended to introduce insects from overseas or rely heavily on pesticides for crop production. But New Zealand's native insects are a valuable untapped resource for farmers."

Howlett has spent more than a decade studying which native insects could pollinate crops on the Canterbury Plains. "We already have small numbers of native insects contributing to crops like white clover, onion, carrot, brassicas and radish. And while we may only have 28 native bee species, they are good crop pollinators – often an equal match for the introduced honey bee."

Davidson and Howlett have been working with local councils, trusts, community groups and key primary industries that represent arable, dairy and beef and lamb farms on the Canterbury Plains towards designing native plant habitats aimed at increasing the abundance of native insects where they are not currently supported by the environment.

"Native bush supports our native insects in many ways", says Davidson. "It provides nectar and pollen for food, protection from the weather, nesting sites and leaf litter, which is used by native flies and beetles to feed and shelter in. Because we now have a much better understanding of the beneficial roles played by different native insect species on farms, we can design native habitats to build their populations."

Davidson and Howlett are employing an "ecological network" approach to select the best mix of native plants. "In addition to knowing which insect species to target for on-farm benefits to production, we have increased our knowledge of which native plant species these insects use for nectar and pollen", says Howlett.

With this knowledge, the scientists can map how native insects interact with native plants and crops so that farmers gain the benefits of both pollination and pest suppression.

> New Zealand's native insects are a valuable untapped resource for farmers.

Dr Melanie Davidson, Biodiversity and Pollination Scientist.

Top: Large hover fly (*Melangyna novaezelandiae*) pollinates a range of native and exotic plants.

Centre: Tasmanian lacewing (*Micromus tasmaniae*) is a predator of aphids in crops.

Bottom: Alexander beetle (*Megadromus antarcticus*) helps control slug populations in the Canterbury region.

> We could be heading into trouble without even realising it.

Another question that needs answering is: how are New Zealand's insects faring overall? A 2019 global scientific review found that 40% of insect species are declining and a third are endangered. In the last quarter of a century or so, total insect biomass has been falling by 2.5% a year.

And here? The Department of Conservation lists 280 species of invertebrates as conservation priorities, many of which are insects. But the bigger picture is unclear according to Pattemore. "We could be heading into trouble without even realising it."

One reason for a lack of data in this country compared with, say, Europe, is that we don't have centuries of amateur entomology groups repeating sampling year after year. But there are a couple of ways to close the knowledge gap. One is to track down studies that have been done here and replicate them. Another is to analyse specimens held by museums and other collections. "With colleagues at Landcare Research, we're keen to explore whether genetic information contained in those samples could provide insights into how populations have changed over time."

Certainly, it would be unwise to think that we've been untouched. Agricultural intensification, loss of habitat, the liberal use of sprays – the causes of insect decline are all in play here.

Beggs applauds efforts to save endangered insects, such as the Mercury Island tusked weta. But with 20,000 insect species out there, "We really have to work at the community or ecosystem level," she says. "How can we restore a bit more function to make sure we're protecting things for groups that we don't even know about?"

Riparian plantings, more wasp control and reducing sprays on farms and in orchards will help. But the public can do its bit, too. "One of the best things you can do is increase the amount of native vegetation in your garden – I shudder every time I see another large patch of lawn. And, people, put your sprays away!"

A peacock mite on a branch. A significant pest in some regions, the name is evoked by their feather-like bristles or setae which can be used against predators.

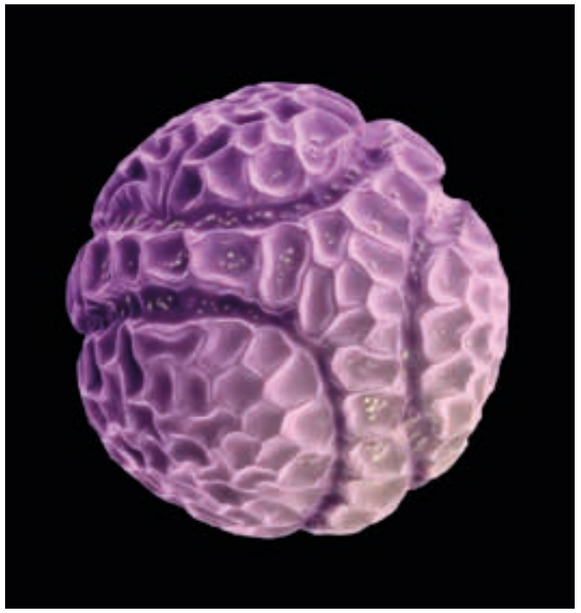
IMAGE BY RIA REBSTOCK
Scientist, Postharvest Fresh Foods

Views from a microscopic world

IMAGES CAPTURED WITHIN THE PLANT & FOOD RESEARCH MICROSCOPY LABORATORY. CURATED AND HAND-COLOURED BY PLANT & FOOD RESEARCH PHOTOGRAPHER WARA BULLÔT.

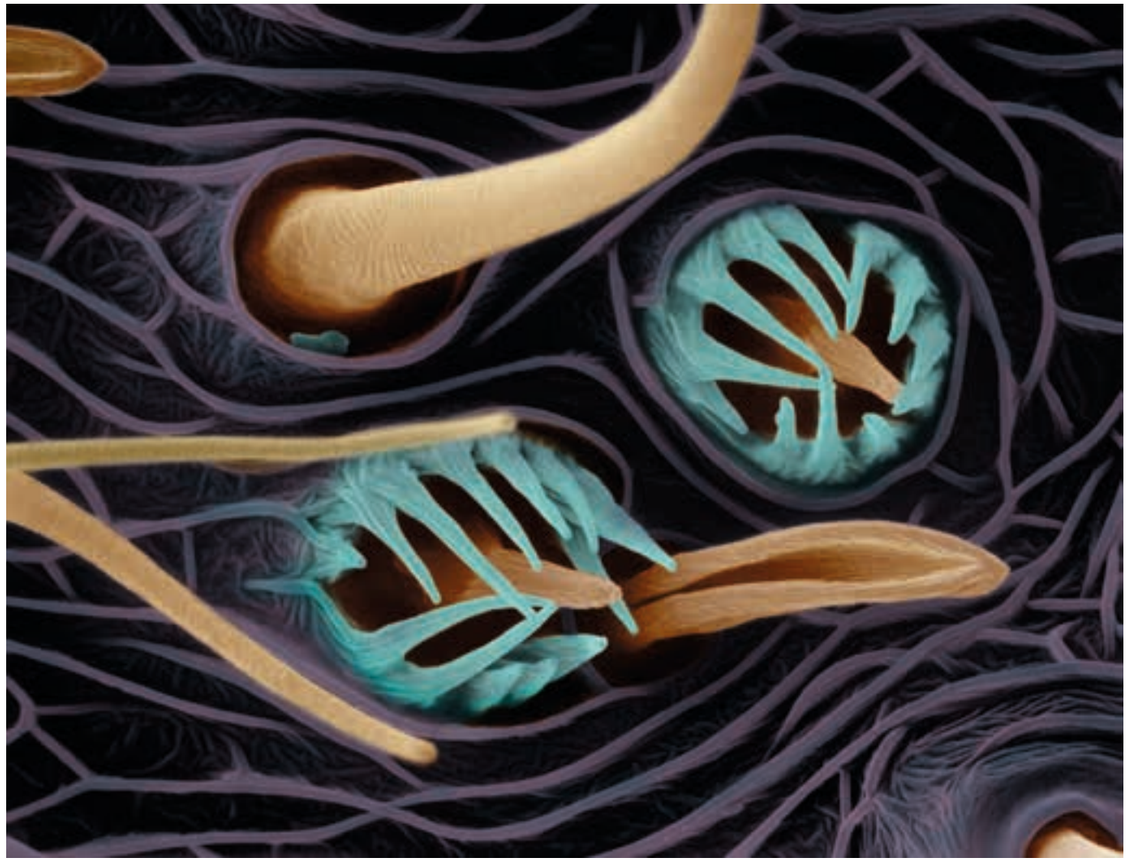
The images in the following pages have been taken using a scanning electron microscope (SEM) as part of Plant & Food Research projects over the last 30 years. By scanning the surface of an object with a focused beam of electrons, SEMs can produce high-resolution images, at magnifications much greater than those captured with a light microscope. Specimens usually require special preparation to preserve or stabilise and increase electrical conductivity, prior to imaging.

SEM images have an intriguing 3D appearance. The original images are captured in grayscale but colour is often added to enhance their appearance and to make the images more visually appealing, as has been done in these photographs. In these images, hand colouring transforms seldom-seen views captured for science into images of curiosity and beauty.



A pollen grain from the common purple-fruited passionfruit variety.

IMAGE BY DR IAN HALLETT
Team Leader, Microscopy & Cell Walls

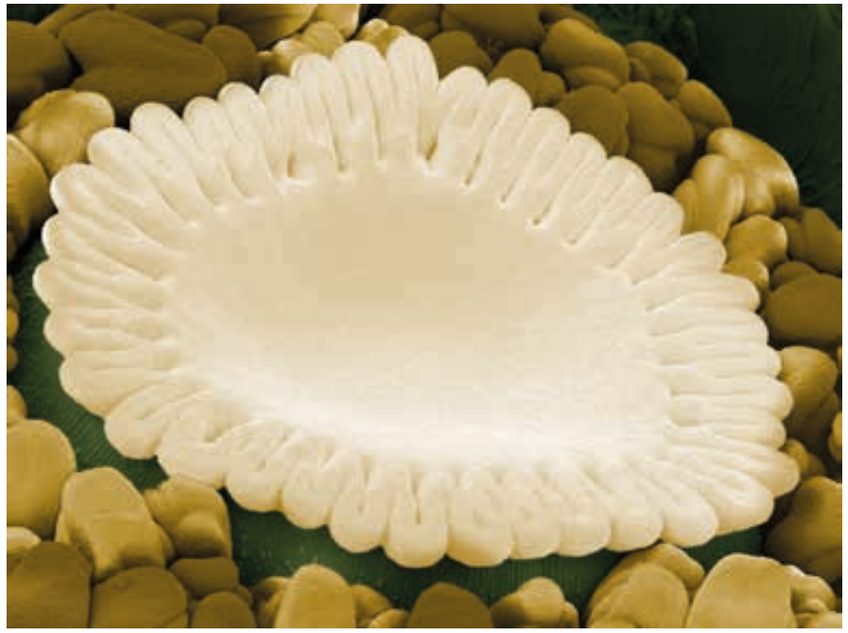


Detail of an antenna from a lightbrown apple moth. The wavy design (background) is the cuticle. Shown in orange are sensory hairs, called sensilla. Volatile odorants enter these from the air and these make up the insect's nose. The aqua-coloured parts are protective hairs found around sensilla pits.

IMAGE BY DR MELISSA JORDAN
Team Leader, Molecular Sensing

The reproductive spores of a rust fungus. Image taken as part of plant pathology research. The mass of spores on an infected plant appear as rust-like patches. When conditions are favourable, the spores can germinate to cause additional infections and spread the disease.

IMAGE BY DR IAN HALLETT
Team Leader, Microscopy & Cell Walls

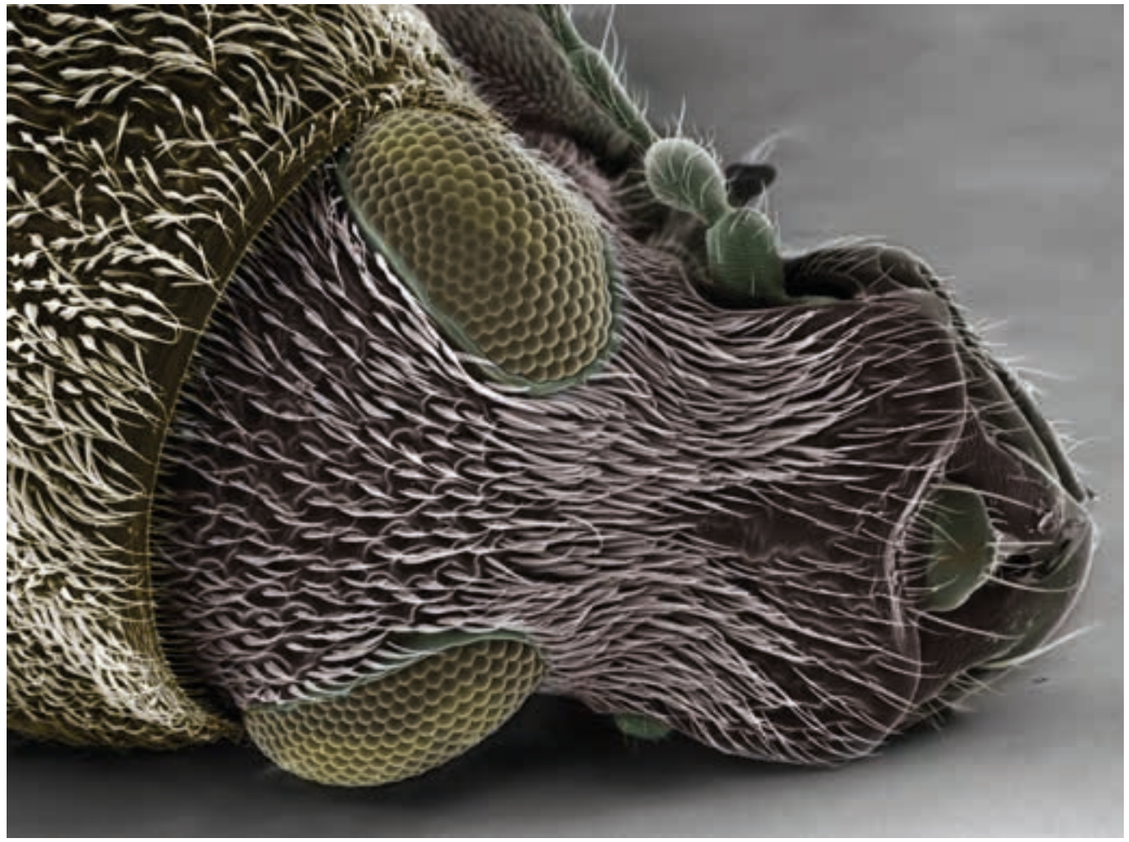


Detail of a developing kiwifruit flower, showing the pollen-bearing anthers (cream) and the inner stigmatic whorl (centre).

IMAGE BY MIDORI JONES
Previously Research Associate at Plant & Food Research

The detail on the head of a weevil (*Pleosporius bullatus*). The image shows the compound eyes, coloured olive green. The hexagonal facets are each a lens that focuses light on a receptor. The antenna and mouthparts are visible in forest green. Insect setae (hairs) can be sensitive to movements or chemicals (smell and taste).

IMAGE BY DR IAN HALLETT
Team Leader, Microscopy & Cell Walls



A gorse thrip image taken as part of a study into whether thrips can distribute spores or pollen. Gorse thrips were introduced into New Zealand from Europe as a means of biological control of the gorse weed.

IMAGE BY DR IAN HALLETT
Team Leader, Microscopy & Cell Walls

The good berry

A blackcurrant is just a blackcurrant. Unless it's a New Zealand blackcurrant!

More than a decade of research has shown that New Zealand blackcurrants are berries with a bit extra. And a new brand is making sure consumers know all about it.

Plant & Food Research and the New Zealand Blackcurrant Cooperative have worked together to create Adaptive™ New Zealand blackcurrants, a new brand to stamp on products that contain the right amount of New Zealand-grown blackcurrants to improve consumer wellness. The Adaptive logo can be used by food manufacturers who want their products to have a point of difference supported by science.

A platform of research has shown that New Zealand-grown blackcurrants have a positive effect on sports performance, recovery and immunity, big market opportunities for the food industry. Displaying the Adaptive brand on foods means that consumers can be sure they're buying genuine New Zealand-grown blackcurrants at a quantity scientifically proven to have benefits.

Mike Callagher, General Manager of the Coop, sees the new branding as a positive step to improving visibility of the scientific data available.

"There are a number of so-called super foods on the market that have no discernible science to back up their claims. The Adaptive brand provides us with a way of showcasing the extensive research demonstrating the positive effects of New Zealand-grown blackcurrants, helping food producers and consumers to better understand the benefits."

Claims backed by the science had already created interest in overseas markets, but the addition of a brand has raised the bar. Callagher notes that the Coop has received a marked increase in enquiries since the launch of the Adaptive brand, particularly from food manufacturers in countries like the USA and Japan, where having solid technical evidence provides opportunities for enhanced marketing and creates a buzz with consumers.

The difference in New Zealand blackcurrants is thought to be partly due to the nation's high UV growing conditions, which create a unique balance of red (cyanidin) and blue (delphinidin) pigments in the ripened fruit. The unique combination of these compounds – from a family of compounds known as anthocyanins – work together when consumed to create an effect which improves the body's adaptive protective and defence systems. This means if you take a defined quantity of New Zealand blackcurrants – 120 mg of anthocyanins – before you exercise, your body switches on pathways that protect your cells from excessive stress and inflammation, aiding a faster recovery. The research has also shown that consuming a 240 mg serve improves natural immunity – blackcurrants are a rich source of vitamin C as well, which is also known to support immunity.

Currently, around 9,000 tonnes of blackcurrants are grown in New Zealand each year. Most of this is processed, into juices, extracts and concentrates, for use as ingredients by food manufacturers around the world. Creating more demand is expected to increase the value of blackcurrants at the farm gate, and provide an attractive option for growers looking to change the way they use their land.

Callagher is keen for consumers to really understand the life-long benefits they can gain from New Zealand blackcurrants so the investment required to expand the industry pays off in the long term.

"Blackcurrant farming requires upfront investment, as plants need to be in the ground for at least three years before they fruit. We're aiming to embed Adaptive New Zealand blackcurrants in the minds of consumers across the world so that we see steady growth with longevity, not a short-lived trend. Capturing even a small portion of the growing functional food market would make a big difference to the New Zealand industry's value."

Researchers study the effects of New Zealand blackcurrants on athletic performance.

Displaying the Adaptive™ brand on foods means that consumers can be sure they're buying genuine New Zealand-grown blackcurrants at a dose scientifically proven to have benefits.

Pūhā/Pūwhā
(sow thistle)

Pūhā/Pūwhā is a staple green vegetable still eaten today by Māori. It is a small leafy plant with thistle-like leaves and milky juice. They are often used in a boil-up with any available meat, such as bacon bones, fish heads and tītī (mutton birds). When eaten raw, the stem and leaves have a bitter taste. The bitterness can be reduced by rubbing the pūhā plants together under running water.

USE
Pūhā had a wide traditional variety of uses, including to restore a patient to health after childbirth, to treat stomach complaints, and to purify blood. The milky sap can be mixed with tarata (lemonwood) gum and used as a chewing gum to get rid of bad breath.

NUTRITIONAL VALUE
This plant contains nutrients good for health including B vitamins (folate and niacin), provitamin A carotenoids and vitamin K. These nutrients are important for blood formation and the circulatory system as well as for reducing tiredness and fatigue.

Kōwhitiwhiti
(watercress)

Kōwhitiwhiti and pūhā are used interchangeably in some recipes. Kōwhitiwhiti is a leafy vegetable with a mild mustard flavour that grows on the edge of freshwater rivers, streams and creeks around the country.

USE
Traditionally, it could be eaten raw or used to wrap food. Kōwhitiwhiti (or pūhā) is also a common ingredient for the preserved dish toroi. The vegetables are cooked together with kūtai (mussels) and stored in jars to undergo fermentation. Today kōwhitiwhiti is commonly cooked as a vegetable in hāngī.

Māori use kōwhitiwhiti roots for skin rashes, scabies and boils. Damp kōwhitiwhiti was also used as a cloth and applied to the head for headaches.

NUTRITIONAL VALUE
Kōwhitiwhiti is high in folate, provitamin A carotenoids and vitamin C, which are important for normal vision, skin and immunity.

Kūtai/Kuku
(mussels)

Aotearoa New Zealand has the ninth longest coastline in the world. It makes sense that kaimoana (seafood) was vital to the Māori diet before settlers introduced crops such as wheat and potatoes and livestock like pigs, sheep and poultry to the land.

USE
Like other shellfish, kūtai were usually cooked on heated rocks or eaten raw. Māori also preserved their seafood by hanging them on poles to dry in the sun or baking first before hanging. Kūtai are still a cultural delicacy enjoyed by Māori throughout Aotearoa today.

NUTRITIONAL VALUE
Kūtai are nutrient powerhouses, being good sources of protein and many important minerals, in particular iron, iodine, zinc and selenium which can often be deficient in some groups of the population. They are also high in B vitamins such as folate, niacin and B12. They have a great fatty acid profile and are a good source of omega-3. Many of these nutrients are important for cognitive function, a healthy immune system and for protecting the body from free radical damage.

New Zealand Greenshell™ Mussels are now exported to many parts of the world and consumed as a delicacy or health supplement.

Kai for thought

Kai (food) has a special role in connecting people and bridging cultures in Aotearoa New Zealand. Many plants and kaimoana (seafood) we enjoy today have been staples in the Māori diet for hundreds of years. Māori innovation and Mātauranga Māori (Māori knowledge) have guided the cultivation and harvest of culturally significant foods for generations.

Karengo
(seaweed)

Karengo is a red sea lettuce native to Aotearoa. It is closely related to the Japanese nori and Welsh laver. Karengo can be either eaten raw, dried, reconstituted in hot water as soup, or used to season various dishes. The flavour changes depending on how it is prepared. When eaten fresh the taste is relatively mild but it has a distinctive fishy taste when dried. It can also be used as a steaming vessel for seafood.

USE
Karengo was an important supplement to the pre-settlement Māori winter diet. It contains significantly more minerals than land plants. Dried karengo was also sent to members of the Māori Battalion in the Middle East during World War II. Today, Māori organisations are exploring new innovations with karengo ingredients.

NUTRITIONAL VALUE
Some Māori recognise the value of this seaweed as a laxative and as a preventative of goitre. The stand-out nutrient in karengo is iodine but it is also high in iron, folate and dietary fibre. Iodine is particularly important for the brain and nervous system, and the production of thyroid hormones.

Kūmara

Kūmara is known as sweet potato elsewhere. It is an iconic food treasured by Māori for its significance, both edible and its use in tikanga Māori (culture and traditions). Kūmara is well loved by Kiwis to this day. Along with many other vegetables, kūmara was brought to Aotearoa from Polynesia by Māori; however, some vegetables did not fare as well in their new home because of the cooler climate, so kūmara became an important element in the traditional Māori diet.

Māori are skilled horticulturists and have adapted these practices for generations. They are essentially early adaptors of biocontrol. Māori traditionally planted large gardens of kūmara on sloping land with bright sunlight and good draining soil. Fences were built to protect the crops from the weather and birds. Māori also kept tame karoro (seagulls) to eat caterpillars of kūmara moths. Kūmara is still recognised as a taonga food by many iwi around Aotearoa and is often used for ceremonial purposes as well.

USE
Kūmara is cooked in many ways – in hāngī, boiled, steamed, or dried in the sun. Traditionally, Māori stored the leftover kūmara in underground pits over winter. Some were for consumption and some for next year's planting. Dried kūmara (kao) was used to make a gruel/porridge for invalids.

NUTRITIONAL VALUE
The nutrient composition of kūmara varies depending on the colour, but they are generally high in dietary fibre, vitamin C, potassium and some of the B vitamins. These nutrients have a range of health benefits including supporting the immune system and helping the body to convert macronutrients, such as carbohydrates, into energy. The functions align with the traditional usage of kūmara.

Kahawai

Kahawai (*Arripis trutta*) is known by its Māori name in New Zealand and as Australian salmon in Australia (although, besides its look, it is not related to salmon or to trout).

USE
Kahawai is an important traditional food for Māori. For example, Māori at the Motu River used to bury the fish for up to a year to preserve them. More commonly today, the fish can be preserved by smoking or bottling. Māori used to fish for kahawai with flax nets or with lures made of wood, shiny pāua (abalone) shells, whalebones and/or pounamu (New Zealand jade). They drew the beautiful lures through the water, attracting the fish with their flashes of colour.

NUTRITIONAL VALUE
Kahawai is a good source of protein, B vitamins, selenium and vitamin D. These nutrients have a wide range of health benefits and in particular are important for physical performance.

For more on the nutrient content of these foods and over 2,700 commonly prepared and eaten foods in New Zealand, visit the New Zealand Food Composition Database at foodcomposition.co.nz. To learn more about Māori traditional and contemporary interests in plant and kaimoana, check out some of the Māori organisations Plant & Food Research has supported in these areas: Wakatū, Tuaropaki and Ngati Porou Miere.

From quantity to quality — shifting thinking about food production

Given New Zealand's commitments to reducing greenhouse gas emissions, changes to our agricultural systems are inevitable. But as we transition it is essential that we keep a lens on nutrition and a focus on quality as well as quantity.

CAROLYN LISTER
Principal Scientist & Team Leader, Food & Health Innovation

Food production already contributes around 30% of greenhouse gas emissions. Over the next three decades, as we figure out how to feed an extra two billion people globally, the pressure on our food systems will only increase. On top of this, much of the food eaten around the world is low in nutrient density and contains too many empty calories.

Nutrition is integral to sustainable development. It's incorporated into the United Nations Sustainable Development Goals (SDGs) as part of health and wellbeing. Globally, nutrient density levels have, reportedly, been falling, although this is debated. We need robust research to understand the impact on nutrition from modifying our food systems.

Transforming our food production systems to optimise sustainability and nutrition is a huge goal. Local challenges and opportunities will require diverse approaches. Although global considerations are important, in New Zealand the approaches will be shaped by the Māori world view and knowledge as well as environmental, geographical and social realities.

The nutritional composition of produce is affected by many things. These include genetics (varieties/cultivars), healthy soils, water, growing location, management practices, harvest time and postharvest handling and storage.

Over the past few years concepts like nutrition-sensitive agriculture have attempted to put nutrition at the heart of agricultural development. In New Zealand, the topic of regenerative agriculture has also been generating debate, promoted as a means to reverse climate change.

Regenerative agriculture includes a system of farming principles and practices that aim to increase biodiversity, enrich soil and optimise water use, among other things. Aside from a lack of clarity and scientific research around some aspects of regenerative agriculture, as we go forward it will be important to understand how changing agricultural practices affect the nutritional value of our foods.

Unlike soils in the USA, where the concept of regenerative agriculture emerged, our soils have not been depleted by continuous cropping. But maybe soils don't need to be depleted for certain management practices to improve their composition and increase the nutritional value of our produce. Even with good soils, a plant may not take up nutrients if it's grown too fast (plants that grow more slowly have more time to take up nutrients). Nutritional composition is also affected by the soil microbiome (the community of microorganisms that live in the soil).

> Aligning food composition data (from the New Zealand Food Composition Database) with other datasets will allow us to develop metrics to guide local nutrition sensitive-agriculture practices and measure food quality, rather than just yield.

A healthy diet involves more than just nutrient-dense produce. Even high nutrient density diets can lack selected nutrients. Vegetarians, for example, may be low in iron, zinc and vitamin B12. Food combinations are also significant for nutrition, with certain combinations able to meet nutritional needs, aid in nutrient absorption and/or ensure complete proteins in plant-based food combinations.

In 2019 the EAT-Lancet Commission proposed the mainly plant-based 'Planetary Health Diet' as a solution to our global environmental and health challenges. While this has spurred the development of a range of new plant-based protein sources, we will need to assess the nutrition and health impacts of new diet choices at a population level as they evolve.

Ensuring that all parts of our food system are optimal in terms of nutrition and sustainability will require an integrated approach based on science to help support the decisions we make, rather than just following trends.

At the grower end we will need to find real, practical solutions. Scientific research will be essential to guiding food producers, manufacturers and consumers to make optimum choices from both a sustainability and a health point-of-view. We will also need to measure impacts from changes to our food system practices and understand them in a dietary context to make sure we don't introduce new problems, such as nutritional deficiencies.

Digital solutions will be vital too. For example, aligning food composition data (from the New Zealand Food Composition Database) with other datasets will allow us to develop metrics to guide local nutrition sensitive-agriculture practices and measure food quality, rather than just yield.

The development of new digital tools will allow consumers to make optimal food choices based on sustainability and health. These tools will open new doors to explore what we could grow locally with a changing climate – consider the peanut growing trial currently underway in Northland. Food manufacturers will benefit as well, by enabling them to design tasty, nutritious new food options with good sustainability footprints.

AI – virtual orchards, insect superpowers and intelligent computer vision

Artificial Intelligence (AI) is the study of computations that make it possible to perceive, reason, and act. AI can enable machines to do jobs that have traditionally required human intelligence. The development and training of AI algorithms often requires some form of human input, but once established these algorithms can increase our capacity to accurately predict and classify information at a much larger scale than is possible using humans, and in much less time.

One of the most important requirements needed to train a robust AI model is a reliable source of high quality data. For science-based AI applications, novel methods are often developed just to capture the high quality data needed to train the algorithm. The AI algorithm is then trained and assessed by leveraging expert knowledge within a particular field to determine how well the AI application performed its desired task.

Virtual orchards

Managing an orchard of the future may be more about understanding its digital twin. With advances in capturing data – including panoramic, infrared, light detection and ranging (LIDAR) and magnetic resonance imaging (MRI) – it is possible to obtain accurate 3D data in just a day or two.

But why create a virtual orchard when you have the real thing? Capturing virtual data at various stages of plant development within and between seasons can support decision-making around investment and cultivar development and help quantify environmental impacts.

As sustainable producers of horticultural products, the technology could support New Zealand's growers. Data on nutrient demand, water and disease gleaned from a virtual orchard can reduce the cost of actions in the real orchard – including preventing negative impacts on the environment. Such data can also assist in forecasting the impacts of environmental changes.

Real-time data can also be used for selection in breeding programmes, maximising the available information for analysis, which can be too resource intensive to collect in the real orchard. And, unlike real orchards, virtual orchards are captured forever. So the data can be stored and revisited at future points in time as new research questions arise.

If this all sounds simple enough, developing AI for orchard or vineyard management is not. It requires massive quantities of robust data and the development of sophisticated models of the orchard system.

"The ability to virtualise spatial data of plants on a whole-orchard scale, coupled with improvements in augmented reality, will massively improve our ability to access, interact with, and understand complex information about our plants," says Dr Peter McAtee, Plant & Food Research Scientist.

McAtee has been working on using AI technology for the past three years and says, "It signifies a step change that will be similar to when we moved from paper to computer-based recording of information. Researchers can expect to see some exciting advances in this field in the not-so-distant future".

Capturing virtual data at various stages of plant development within and between seasons can support decision-making around investment and cultivar development and help quantify environmental impacts.

Harnessing insect superpowers

Insects are known for their incredible sense of smell. Consider how long it takes them to discover uncovered food.

As Dr Andrew Kralicek, Chief Technology Officer, Scentian Bio, says, "Insects' primary sense is smell. 400 million years of insect evolution has made them incredibly sensitive to volatile organic compounds."

He should know – having spent close to two decades searching for a way to harness this amazing sense of smell for human use.

Insects derive their smell superpower from their smell receptors. Combining insect smell receptors with state-of-the-art biosensor formats, Kralicek and his team have developed a prototype sensor that enables synthetic insect receptors to be used to detect tiny quantities of volatile compounds. Their technology has the capacity to revolutionise electronic sensors as we currently know them, detecting volatile organic compounds down to the parts per quadrillion level. But it has to be taught how to smell, which is where AI comes in.

Developing the technology involves pairing sensor chips with machine learning algorithms. In this way the smell receptors are 'translated' using AI into digital information about target aromas and flavours. This pairing of the sensor chip with AI means many sensors can be put onto a single chip to detect a range of compounds in a single sample, based on the digital signals produced. The chips can be integrated into existing sensor platforms or used for new devices and applications.

The potential applications are enormous. On the list are: detecting cancer, identifying pest incursions, checking air and food quality, alcoholic beverage production and even detecting explosives.

Kralicek and his team are taking their technology into commercial development, with the goal of developing novel sensors for specific uses. These hand-held, selective and highly sensitive sensors will provide a cost-effective alternative to current sensing technologies like gas chromatography-mass spectrometry (GC-MS).

The potential applications are enormous. On the list are: detecting cancer, identifying pest incursions, checking air and food quality, alcoholic beverage production and even detecting explosives.

Intelligent computer vision

Manually identifying, counting and measuring plants, insects or sea creatures for horticultural and aquacultural applications can be enormously time consuming. Training computer models to do this job quickly and reliably allows more time to be spent analysing datasets and less time collecting them. It can also enable entirely new data collection methods that weren't previously possible.

Data Scientists at Plant & Food Research, Daniel Bentall and Harris Lin, have developed an intelligent computer vision platform aiming to make computer vision more accessible and affordable, which is suited to a range of applications.

"To enable the automation of image recognition, images first need to be annotated by people. The annotations are used to train a machine learning model how to perform the task," says Bentall.

The platform can perform a range of tasks such as counting objects, detecting disease or estimating size, and has many potential applications, including for phenotyping, monitoring and crop management. So far it has been applied to projects like detecting leafroll disease in grapes, counting kiwifruit on vines and tracking growth of pea seedlings.

Intelligent computer vision detecting leafroll disease in grapes.

Quick facts

Zespri® Red Kiwifruit

An exciting new kiwifruit with vibrant red flesh and tempting berry flavour

In partnership, Zespri® and Plant & Food Research have established what is now the world's leading kiwifruit breeding programme. Its latest release is a cultivar called Zespri® Red, known as Red19, and marketed as **Zespri® Red Kiwifruit**.

It has high levels of Vitamin C, potassium and phenolics. Its **low Glycemic Index (GI)** means it's a suitable fruit for consumers monitoring their blood sugar levels.

The cultivar was commercialised in December 2019, and Zespri has licensed **150 hectares** to be grown in New Zealand.

The red colour is due to the presence of **anthocyanins**, which are associated with health benefits.

In 2018, **Singapore** became the first international market to trial this exciting cultivar, with Japanese consumers having the opportunity to taste it for the first time in 2020.

Zespri® Red has proven popular with a **younger demographic** of consumers who find it new and exciting.

Zespri® Red harvest in New Zealand commences in **early to mid-March** each year, depending on the season. With limited volumes as supply increases to commercial levels, and a short selling window, Zespri® Red is an extra special treat.

Unlike other commercially available red kiwifruit cultivars, which are predominantly red only in the centre, Zespri® Red displays **beautiful red colours** from its centre to the skin.

As with most red kiwifruit cultivars, it can ripen quickly so is **best kept refrigerated** to maximise shelf life.

INSIDE SLICE

At Plant & Food Research, we believe science can create a better future.

By finding smarter, greener options today, we're helping secure the world we want to live in tomorrow. With our partners, we use world-leading science to improve the way they grow, fish, harvest and share food.

A smart green future. Together.

Plant & Food™ Research
Rangahau Ahumāra Kai

A smart green future. Together.

Every day we have 1000 people working across Aotearoa New Zealand and the world to help deliver healthy foods from the world's most sustainable systems. Here's what a smart green future means to them.

For me, a smart green future is a future where our people are reconnected with our whenua, taonga and language. A smart green future is the revitalisation and evolution of customary practices and knowledge systems to enable us, as tangata whenua, to lead research that is of value to us and Aotearoa.

DR MATTHEW WYLIE
Scientist, Seafood Production

It's about providing the idea, the thinking, the science, the path, the tools to make that smart green future a reality. It's not good enough to think that what is acceptable today will be acceptable in future. It's about having the courage to look to the future and knowing we have the ability to create the best outcomes.

DR SUZY BLACK
Team Leader, Physiology & Behaviour, Seafood Production

It's about creating the best possible future for Aotearoa. It means using science to create sustainable opportunities for all New Zealanders – whether that's creating jobs, protecting our primary production and native ecosystems, or producing the most sustainable premium produce. Aotearoa is unique so there's no one-size-fits all approach – in fact, it is about exploring that uniqueness. Being smart is about world-class science, but it's also about collaboration, considering multiple perspectives to create the best future outcomes.

DR ROBIN MACDIARMID,
Team Leader, Virus & Like Organisms

It's about making sure my mokopuna can be involved in primary industries. I love how science can help us understand the way things work and help us find smarter approaches to farming. At Plant & Food Research we use science that has been tested in the real world, to constantly improve best practice. I used to work on my family farm but now as part of the Plant & Food Research whanau, we are working for the whole of Aotearoa New Zealand

DION MUNDY
Scientist, Plant Pathology

A smart green future, to me, is a future where our food and materials production systems integrate cutting-edge technology and a culture of sustainability in a way that enhances and adds value to the ecosystems we engage in. It's about thinking as a community of people, as stakeholders in nature, and as caretakers of scientific legacy – to leave our country and planet in better shape than we found it.

DR JAY JAYARAMAN
Scientist, Bioprotection Technologies

To me, from the perspective of technology development, a 'smart green future' means several things. Of course, it includes creating 'future' products and technologies. But it's also about sustainability, which has become more of a priority; this means our products and technologies will be directed towards 'green' solutions. Technology development needs to be 'smart'. The S.M.A.R.T. acronym fits well. 'Specific' in that it solves a real world problem. 'Measurable' and 'achievable' describe the fast-fail approach that technology development takes. 'Relevant', because it uses the collective expertise and capabilities of our organisation, and 'time based', because technology needs to get to market quickly.

DR KIERAN ELBOROUGH
Group General Manager, Technology Development

A smart green future is about building on the knowledge we have. It means being open to new ideas through connecting and including different perspectives so that we, as global citizens, create the future we want. We won't build a better future by carrying on with business as usual. But long-term vision, combined with the opportunities presented by science, has the potential to create a green, healthy and plentiful future that will benefit the generations to come.

DR SAMANTHA BALDWIN
Group Leader, Annual Crops

THE NUMBERS

14 sites across New Zealand as well as offices in Australia and the USA

1000 total staff

750 science staff

424 ha research farms

Our Strategy

We believe our science can make the world a better place. That by working together, we can create a smart green future for Aotearoa New Zealand and the world.

We invest in our people, our facilities, our information systems and in future science. We believe that these are vital parts of creating an organisation that delivers world-class science.

We know our science can only make a difference if it is applied outside the lab. We build relationships with customers and partners, including with Māori organisations, to find the best ways for our science to help their businesses grow.

We then share our knowledge and skills, so that our customers, our partners and Plant & Food Research itself receive fair value from the results of our science. We provide R&D services for those that need it and create pipelines of new technologies for commercialisation, either directly by us or in partnership with others.

For us, a smart green future means we use all available knowledge to produce healthy, nutritious food from the land and sea, while ensuring we protect our environment and create opportunities for future generations.

Our strategy has three elements that together will deliver a smart green future for Aotearoa New Zealand:

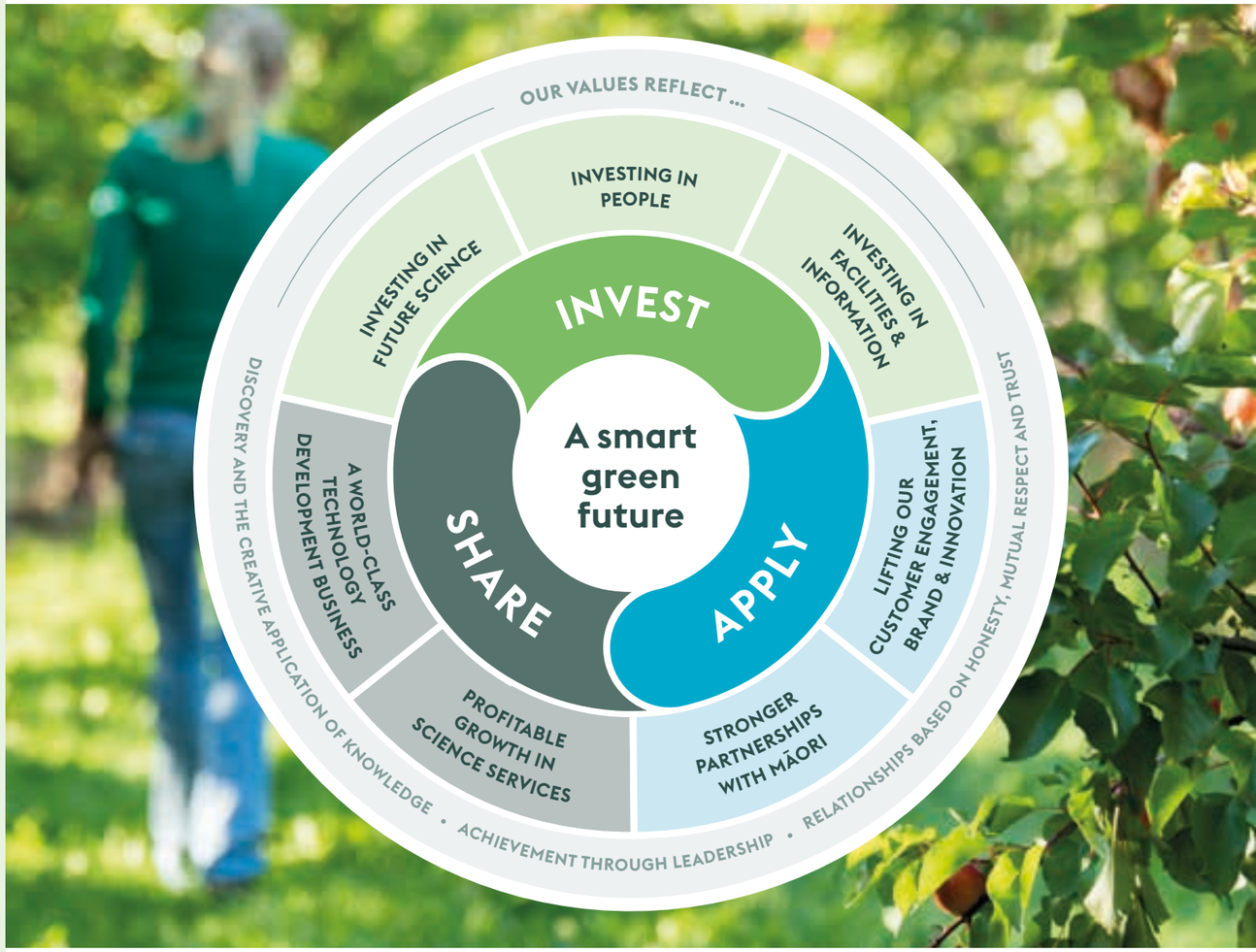
1. Invest / Whakangao
   to create world-class science
2. Apply / Whakamahi
   that science to create maximum value
3. Share / Tuari
   that value fairly with those who have contributed to its creation to increase the sustainability of their businesses.

This strategy is realised through seven strands that ensure our activities align with the requirements of our Institute, our customers and our partners.

Meet some of our leaders:

Name: Blake Mackie
Position: General Manager Revenue & Growth (joined Feb 2021)
Education: Bachelor of Science (Hons) Lincoln
Interesting fact: Combining two of my favourite pastimes, I managed to finish the Medoc Marathon in Bordeaux which substituted water stations for wine tasting
Favourite foods: Kiwifruit, seafood and berries

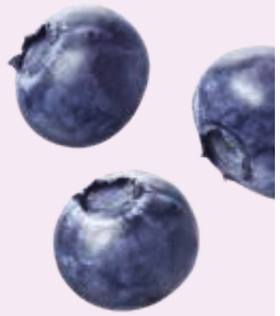
Name: Nadine Tunley
Position: Board member (joined March 2020)
Interesting fact: Was Chair of NZ Apples & Pears when it was the first industry to reach the Governments 'Growth Agenda' of doubling of export value by 2025
Favourite Foods: Raspberries and lemon meringue gateaux



Our activities are funded through direct commercial research for our customers, the reinvestment of royalties and the New Zealand Government's investment in science.

$43.1M	$13.1M	$51.6M	$50.4M	$8.8M	$1.9M
Strategic funding	**Contestable**	**Royalties**	**Commercial**	**COVID-19 recovery funding**	**Other**
Government investment allocated directly to each Crown Research Institute	Government investment allocated through competitive bidding	Commercial return from plant varieties and IP	Direct investment by customers	Government allocated COVID-19 funding	All other income sources

Bigger better blueberries



Premium blueberries are in demand globally. To help fulfil the consumer desire for bigger better blueberries, Plant & Food Research and T&G Global have formed a new partnership. The goal is to breed tastier, ampler berries with improved yield, disease resistance and an extended window for harvest.

The new partnership is looking to breed and commercialise exciting new varieties, the first of which could be launched in as little as 12 months. The berries will be marketed under T&G Global's Orchard Rd brand, to help deliver them to key Asian markets.

Plant & Food Research has a long relationship with T&G Global dating from the 1990s. The blueberry partnership builds on the success of premium apple brands like 'Scilate'/ENVY™ and 'Scifresh'/JAZZ™. The new partnership will allow T&G Global to access a pipeline of research-bred and licensed blueberry varieties.

Naturally athletic

2before™ is a newly launched sports performance enhancer that uses science to boost the natural power of New Zealand blackcurrants.

"Research findings demonstrate that a specific concentration and mixture of anthocyanins is required to gain sports performance benefits and that timing is important," says Dr Roger Hurst, Principal Scientist, Nutrition & Health at Plant & Food Research.

Hurst and his team have been researching the benefits of New Zealand blackcurrants for over a decade and have contributed to the 24 internationally published scientific studies showing that consumption of the berries can assist with sports performance and recovery, among other benefits. A recent review and analysis of the scientific evidence globally, for example, looked specifically at the sports performance benefits of New Zealand blackcurrants and confirmed that they were robust and significant.

The name 2before™ reflects the optimum timing for consumption – two hours prior to the time an athlete wants to be performing at their peak. The required concentration and appropriate mixture of bioavailable anthocyanins are delivered via the 'shot' format of the product.

What makes New Zealand blackcurrant berries special? They contain high concentrations of anthocyanins in a unique mix of red antioxidants (cyanidins) and blue pro-oxidants (delphinidins). This mix appears to activate the body's adaptive pathways, triggering protective and defence systems. "The blackcurrant anthocyanins provide a unique mechanism of action unlike traditional antioxidants, supporting training adaptation, recovery and improved immunity," says Hurst.

Brendan Vercoe, CEO of 2before™, says the product delivers for consumers who are looking to enhance performance, recovery and wellness but also increasingly want products that are "natural, sustainable, vegan and non-GMO."

2before™ is made from Adaptive™ New Zealand blackcurrants, a newly developed brand managed by the New Zealand Blackcurrant Cooperative. The brand provides assurance to customers that they are purchasing genuine New Zealand blackcurrants delivering anthocyanins at concentrations scientifically validated to have biological effect (see page 24).

Hotter apples

Can modern breeding techniques produce an apple that thrives in a hot climate? The answer is yes. Meet 'HOT84A1', the first apple to be launched out of the Hot Climate Programme, a research collaboration between New Zealand and Spain.

The new apple has an intense red colour and is crisp and juicy. Many markets, particularly Asian markets, favour red colour in apples; however, redness can fade when traditional apples are grown in weather that's too hot.

The Hot Climate Programme was born of problems faced by growers in Northern Spain. In warmer temperatures growers were faced with sunburnt, faded-looking apples with soft flesh and storage disorders.

"The high summer temperatures caused apples to lack their usual colour and crunch," says Dr Richard Volz, Science Team Leader at Plant & Food Research, who has worked on the Hot Climate Programme for over a decade. "Not only was it likely this region would face hot summers in future but other regions are also likely to experience them."

To help future-proof our apples, Plant & Food Research, along with IRTA and Fruit Futur in Spain initiated The Hot Climate Programme in 2002 with the goal of breeding new varieties of apples and pears tolerant to hotter temperatures. Breeding new cultivars not only helps safeguard the livelihood of existing growers but also offers new opportunities in regions previously too hot to grow these fruit.

"It's exciting to see the first variety launched," says Volz. "New commercial varieties represent years of testing to ensure we are growing fruit that people want to eat. We also need to be able to grow and store the fruit so that the eating experience is consistent and growers can manage their orchards appropriately."

The first commercial trees are due to be planted by Fruit Futur on the Iberian Peninsula in early 2021 and a network of growing partners in New Zealand, South Africa, Europe, the UK and Australia have been identified for grower testing by Plant & Food Research's commercial partner T&G Global. Plantings will take around three years to bear fruit.

Collaborating with Māori groups to conserve taonga fish and plants

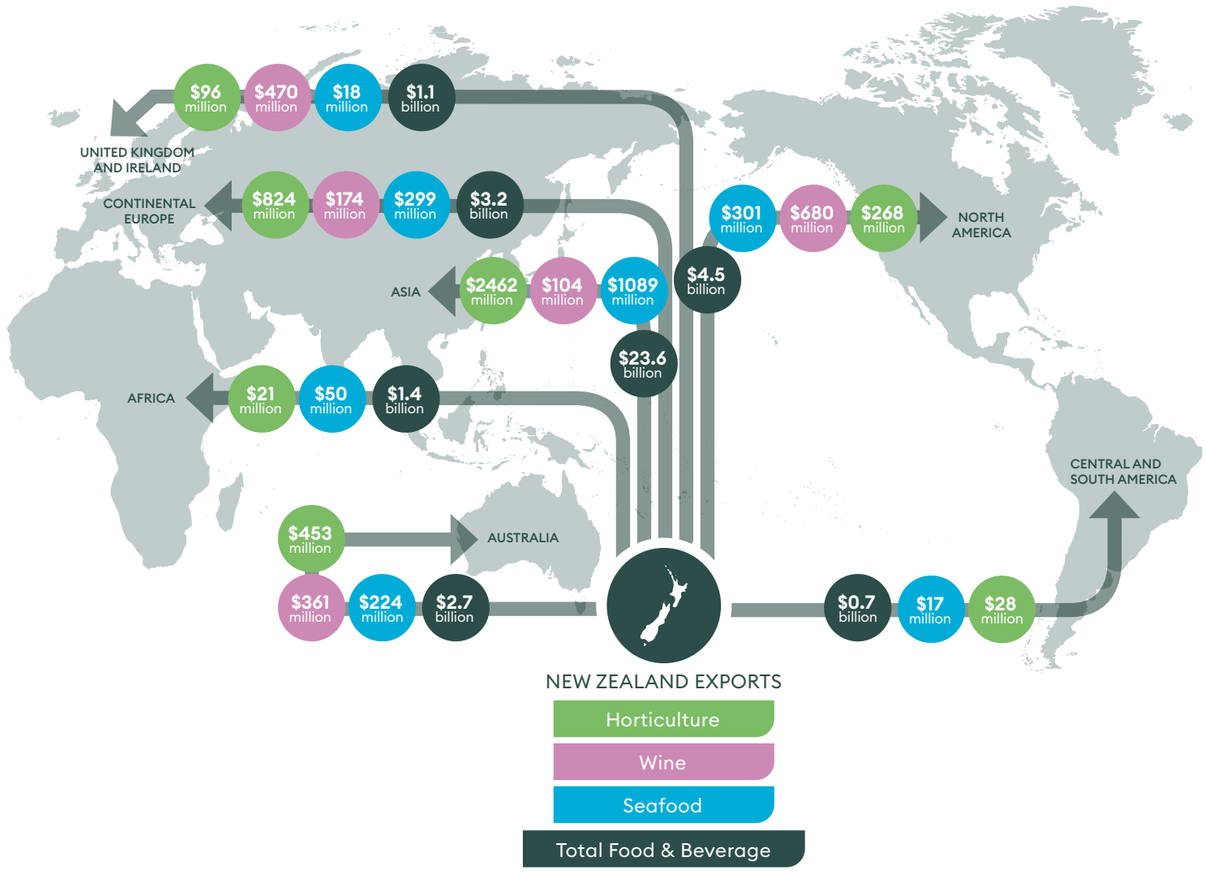
Two new projects backed by MBIE's Vision Mātauranga Capability Fund aim to build new connections between Māori organisations and Plant & Food Research.

The first project – "Contemporary kaitiakitanga (guardianship and protection) of freshwater taonga in Aotearoa" – will explore the ethical, methodological and cultural considerations that should guide the development and use of cryopreservation and surrogacy tools for fish that may assist iwi and hapū with the conservation, captive breeding and recovery of their freshwater taonga species. In collaboration with Ngāi Tahu/Kāi Tahu, this project will be led by Plant & Food Research aquaculture scientist Dr Matthew Wylie (Ngāi Tahu, Ngāti Māmoe, Waitaha) and Dr Maren Wellenreuther, Group Leader of Seafood Production.

The second project – the "Ūawanui Cultural Nursery Project" – will provide vocational training to upskill eco-warrior cadets in nursery management and plant germplasm conservation, with a key focus on the rohe flora. These skills, together with expertise in plant propagation and an understanding of the ecology of the ecosystem, will enable the development of the Ūawanui Nursery. The project is being coordinated by Dr Jocelyn Eason, GM Science Food Innovation at Plant & Food Research and Te Aitanga-ā-Hauiti Centre of Excellence.

Our sectors

In 2019, New Zealand exported close to $35 billion of food and beverage products, 66% of the country's total exports. Plant & Food Research works with partners across the food sector to create new knowledge and technologies. These support development of the most sustainable food production systems in the world, delivering products that meet the demands of the most discerning global consumers.



Horticulture and wine – year to 30 June 2019
Seafood – year to 31 December 2019

PLANT HEALTH HEROES

Plants provide food and oxygen for humans and animals. Yet the importance of plant health is not always recognised. According to the Food & Agricultural Organisation (FAO) of the United Nations (UN) around 40% of global food crops are lost because of pests and diseases. To promote awareness of the importance of plant health the UN made 2020–July 2021 the International Year of Plant Health. Plant & Food Research scientists are some of New Zealand's plant health heroes:

DR IAN HORNER

Ian has developed critical techniques to aid management of kauri dieback disease.

"The biggest threat for plant health globally is the movement of pathogens, which end up where they shouldn't be, introduced accidentally or through ignorance. This causes so much damage in ecosystems around the world."

DR NICK WAIPARA

Nick (Rongowhakaata and Ngāti Ruapani ki Turanga) advocates a multi-disciplinary approach that engages the community and draws together Western science and indigenous knowledge (Mātauranga Māori) to fight diseases like kauri dieback.

"Everyone can play a part in promoting plant health and preventing disease."

DR GONZALO AVILA

Gonzalo is leading the world's first pre-emptive biocontrol programme against the crop-eating brown marmorated stink bug (BMSB).

"Biocontrol is a cornerstone of integrated pest management. It's a natural and sustainable way to control pests and diseases that threaten plants and our food sources."

DION MUNDY

Dion is known as the 'vine doctor' for his work on understanding and managing grapevine diseases.

"I'm invested in helping the wine industry succeed. I grew up in a vineyard, so I have grown up with the industry."

DR ROBERT BERESFORD

Robert developed a climatic risk model to help analyse patterns of myrtle rust infection.

"Understanding how the disease would react to local conditions was crucial for planning a response strategy for our New Zealand species."

DR LUCIA RAMOS ROMERO

Lucia views plant pathogens as a kind of puzzle. Each piece is a clue that could help fight plant diseases.

"I think the community needs to understand that plants can become diseased. And science has the capacity to help manage plant diseases in many crops."

DR BOB FULLERTON

Bob has been helping improve horticulture in developing countries for 45 years. Since 2013 he has led the fight in Vietnam to control canker, the most debilitating disease of dragon fruit.

"New Zealand is an affluent country with support systems. People in Vietnam don't have that. If we can make a difference by helping them make some money, we should."

DR PHIL ELMER

Phil, along with a team of researchers and industry specialists, identified a candidate suitable for biological control of Psa, the devastating kiwifruit vine-killing disease.

"A new plant disease coming to our shores is inevitable; the key is preparation. Using New Zealand's naturally occurring microorganisms as safe and effective biological controls to fight disease makes perfect sense, as they are already part of our environment."

DR JESSICA VEREIJSSEN

Jessica is working on an Integrated Pest Management best practice for the strawberry industry to combat thrips, an insect that feeds on strawberry leaves, pollen and fruit.

"Sometimes growers show up at my work unannounced or send me photographs of their crops after hours, to ask for help. I don't mind that. I'm like an emergency plant doctor to them."

To find out more about these plant health heroes visit **www.plantandfood.co.nz/page/iyph-home**

A smart green future. Together.

Plant & Food™ Research
Rangahau Ahumāra Kai

ALJ | 3/21 | J009149