Always the bridesmaid, never the bride

"Always the bridesmaid, never the bride" is the saying, but for so long postharvest was more like the weird relative that no one wanted to invite. A strange combination of biology and technology that didn't quite fit – the study of what happens to bits of plants when they are cut off and how to stop them going bad. But with a global focus on food waste, population growth and climate change, postharvest biology and technology have never been more relevant.

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When the agricultural revolution began 10,000 years ago there were 5 million people; today there are 7.6 billion. Over that time agriculture and horticulture have evolved, adapted and revolutionised to feed the world, one of mankind's outstanding achievements. That is not to say that everyone today is sufficiently fed and nourished, they aren't, and as the population is forecast to increase to 11 billion people by 2100, farmers will need to produce more food.

Given that need, reducing food loss and waste from current levels by understanding the postharvest biology of crops and the use of technology will play a significant role in continuing to feed the world. The FAO estimates that about one third of all food produced is either lost before it gets to market, or is wasted, because it is unsold or is not eaten by the consumer (the FAO has recently refined its estimates of food loss and waste: http://www.fao.org/state-of-food-agriculture/en/). Though lost food is bad enough in itself, it also represents wasted land, water, pesticides, fertilizers, greenhouse gas emissions and time, so reducing food losses is also good for the environment and makes economic sense.

This article is not intended to be a comprehensive postharvest review, but I will try to show what postharvest biology and technology has achieved and what I think it still needs to do, and discuss some of the difficulties that I see growers facing and where they need to be supported by research and policy.

Regulation and certification

Regulation and certification is a good place to start. Agricultural and horticultural production, including postharvest operations, take place in a legal and regulatory framework to protect the consumer and indeed everyone in the supply chain. As well as being legally compliant, a grower exporting to the EU will also operate under a good agricultural practice (GAP) scheme, most likely GlobalGAP (https://www.globalgap.org/uk_en/), and will have HACCP-based procedures in place to ensure food safety.

Though GlobalGAP now widely serves as an entry-level pass for growers to European retail and wholesale markets, it is not the only scheme. The International Trade Centre Standards Map (https://sustainabilitymap.org/standards) lists 31 private, 8 public and 2 international standards for fresh fruit exported to Europe, and this does not include in-house audits developed by retailers themselves. In addition to GAP, retailers are also likely to demand that growers are audited against ethical standards such as SA8000 (http://www.sa-intl.org/index.cfm?), BSCI (https://www.amfori.org/), SMETA (Sedex - https://www.sedexglobal.com/) and GRASP (GlobalGAP). With so many GAP and ethical standards available, one problem faced by growers is that different customers accept different standards. So, for example, a BSCI accredited grower that would be widely accepted in mainland Europe is likely to find that a SMETA audit is demanded for exports

to the UK. When customers demand different certifications and audits it creates a burden of cost and time on growers, particularly those exporting to several customers in different countries or regions either directly or through an importer. A mango grower in Côte d'Ivoire commented to me that of his five-week season he spends two weeks with auditors – that is not the best use of his time.

Growers are audited against GlobalGAP and other standards by independent auditing companies. The credibility of any standard depends on the credibility of those auditing it, but unfortunately the quality of these companies' work is not always uniform. This is why some retailers have developed their own audits or accept certifications only if audited by companies they approve, further adding to the audit burden on growers. Even though much of this activity is invisible to the consumer, there is a risk that with so many standards, in-house audits and auditing companies poor practice or even fraud by one of them exposed in the press or on social media will erode public trust in all of them.

Each standard or in-house audit owner no doubt believes that it covers product safety, the environment, and worker welfare better than the others, but why are so many needed and what value do they genuinely add? A quick glance at different standards suggests that there is considerable overlap and redundancy. Tesco in the UK discovered that its GAP scheme, called Nurture, which in fact pre-dated GlobalGAP, meant very little to its shoppers, and acknowledging the appreciable overlap between Nurture and GlobalGAP decided to make it a GlobalGAP module in 2017. This was a welcome reduction to the audit burden for many growers, but more could be done. Benchmarking different standards and establishing equivalency would help progress towards a less fragmented regulatory and certification landscape, which would allow growers to focus their resources on producing safe, high quality food rather than on passing audits.

Postharvest tools: temperature, atmosphere and ethylene

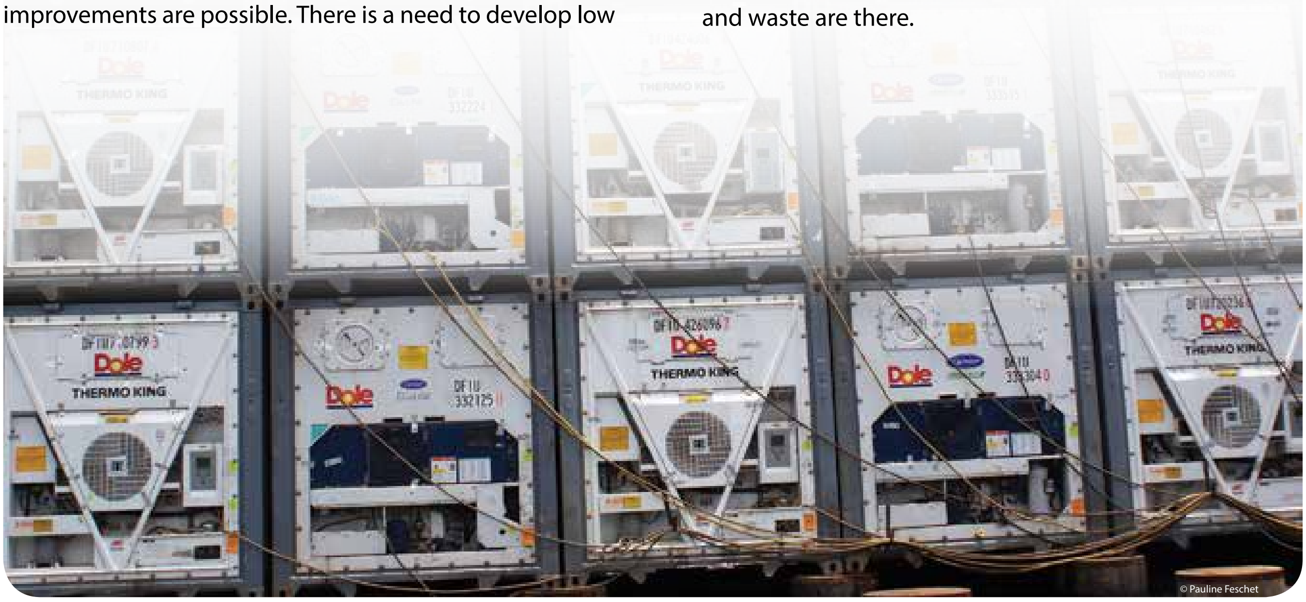
The pillars of postharvest handling are the control of temperature and atmosphere, which are metabolic switches, and of ethylene, which is a developmental switch. Turn down the temperature or the O2 and you turn down metabolism; control ethylene and you control ripening and senescence. The cool chain, controlled and modified atmospheres, and ethylene management are thus the fundamental tools of postharvest handling used to prolong storage life and prevent spoilage.

Temperature control

The refrigerated container, or reefer, is at the heart of tropical supply chains, allowing fruits to be shipped over routes taking several weeks. Suitable temperatures for tropical and exotic fruits are known, but not in the precise way they are for some fruits such as apples, for which optimum temperatures are defined for variety, source and season. Getting the temperature right is important not only for fruit quality, but also for reducing energy costs. It is particularly important for tropical fruits, because they are susceptible to chilling damage at higher temperatures than temperate fruits, and this imposes a higher lower limit for the cool chain, typically about 14°C. Mangoes are susceptible to chilling damage below about 12.5°C, but fruit is regularly shipped at 12°C, 10°C and even 8°C. A small amount of research has looked at the effects of low temperatures on chilling damage in relation to variety, source, harvest maturity, speed of cooling, and the low temperature duration, but there is still more that could be done to optimise transport and storage temperatures not only for mangoes, but indeed practically all tropical fruits.

In the tropics, where infrastructure and energy are often lacking, difficult to access or too expensive, good cool chain management is often a challenge, but advances in renewable energy generation and storage could mean that improvements are possible. There is a need to develop low cost, energy efficient pre-cooling systems, cool rooms, and refrigerated transport using these technologies, coupled with policies that facilitate access for small as well as large growers through subsidies or grants.

As central as the reefer has become to supply chains, it is essentially a dumb piece of technology. An intelligent reefer however would collect temperature, humidity, CO2 and ethylene information about each pallet of fruit and send it to the importer or freight operator so that quality, shelf-life and potential issues were known before the fruit arrived. This would allow improved FIFO operations (first in, first out) in which products with a shorter storage potential, for example, could be used out of rotation or targeted to nearby customers. Studies of fruit, meat and fish where FIFO+ or FEFO (First-Expired-First-Out) was used had typical waste savings of 14%. The Intelligent Container Project (http://intelligentcontainer.com/en/home.html) led by researchers in Germany developed a successful prototype and showed how it might work with bananas. Data from the sensors in each pallet are relayed to a reefer management unit that then sends the information to shore either via a satellite unit or through the ship's communications system. As successful as the prototype was, not all the building blocks for a commercial container yet exist and there are still technical issues to overcome. Further developments in sensor technology, and in quality and shelf-life modelling are also needed. Remote container monitoring (RCM) services that send information about each container to shore do exist, as do wireless temperature sensors, but the problem is that they can't talk to each other, because they use proprietary communications protocols rather than open standards. A further barrier is working out a business model that divides the benefits and costs of intelligent containers between the different stakeholders in the supply chain – the farmer or producer who has to put the sensors in the pallets, the logistic service provider who has to invest in the containers and associated equipment, the importer or distributor who gains most from FIFO+, and the retailer who gains a more consistent product and happier customers. Can the technical and commercial obstacles be overcome? If so, the benefits of reduced loss and waste are there.



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Controlled and modified atmospheres

Managing the atmosphere around fruits by reducing the O2 concentration and increasing the CO2 concentration slows their metabolism much like reducing the temperature. For storage rooms and reefers the atmosphere is managed actively by adding or removing nitrogen, oxygen or CO2 to achieve the desired mix and is called controlled atmosphere. For pallets, cartons and packs the fruit is sealed in a bag and the gas mix is achieved passively by fruit respiration, which uses O2 and releases CO2. This is called modified atmosphere. There are optimum concentration ranges for O2 and CO2 for different fruits as there are optimum storage temperatures. These are important, because if the O2 concentration is too low or the CO2 concentration too high, respiration becomes anaerobic or fermentative, which can lead to off flavours and aromas, and even tissue damage. While managed atmospheres affect primary and secondary metabolism, and so can be considered a metabolic tool, its effect is partially and sometimes even mostly due to an effect on ethylene production and reception, and so it also has development effects.

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Controlled atmosphere (CA) is used extensively for apple and pear storage, and for the transport of bananas and avocados. Recent improvements to the technology allow gas concentrations to be very precisely controlled so that low and ultra low oxygen atmospheres are achievable in which the O2 concentration is held very near or just above the point at which respiration switches from aerobic to anaerobic. Like simple reefers though, such systems are still essentially dumb, but the addition of a sensor to monitor the fruit for signs of stress so that the oxygen concentration can be adjusted makes them intelligent or least dynamic. The sensors detect volatile fermentation products released by the fruits or use chlorophyll fluorescence, which changes when the fruits are stressed. Such systems are called dynamic controlled atmosphere (DCA).

Modified atmosphere packaging (MAP) is used for fruits including pomegranates, bananas, passion fruit, blueberries, litchis and figs. MAP is a successful technology, but its success is intimately tied to polymer science and the properties of the films used to make the bags. For MAP to work a bag must have specific permeabilities to O2, CO2 and water vapour that will depend on the fruit, its respiration rate, the ratio of fruit weight to bag volume and surface area, and the storage temperature. MAP systems therefore need to be finely tuned to the fruit. A recent innovation from Perfotec (https://perfotec.com/) in the Netherlands does exactly that with a system that measures the respiration rate of the fruit or vegetable and then generates a film with optimum gas and vapour permeability achieved by adjusting the number of microperforations in it made by a laser perforator.

The Achilles heel of MAP has always been that the respiration rate of fruit and the gas permeabilities of films do not change with temperature in the same way. A break in the cool chain during transport can therefore have catastrophic consequences as respiration increases, the CO2 concentration shoots up and fermentation ruins the fruit. Similarly a MAP bag that works during transport and storage may not be suitable for the retail shelf if the temperature difference is too great. The answer would be a film with permeabilities that change with temperature so that gas concentrations stay within range. Landec Corporation (https://www.curationfoods.com/) developed such a MAP bag more than 20 years ago that for a long time was licensed to Chiquita Brands for its Chiquita-To-Go single bananas. The Landec bag allowed them to be sold where deliveries are less frequent, sales are slower and the temperature is unpredictable such as gas stations and convenience stores. The technology, called BreatheWay®, is still used by Curation Foods for a small range of processed plant-based foods such as guacamole and salad kits. How relevant such films will be in future for fresh fruits depends on whether a temperature sensitive film can be developed at affordable cost.

A large part of the benefit of MAP is in reducing water loss from fruits, which maintains their freshness and appearance. MAP films however have tended to have low water vapour permeability that results in a near saturated atmosphere inside the bag so that even a small change in temperature causes condensation. Newer films though like the Xtend® films from StePac (StePac was acquired by the Johnson Matthey Group in 2015 - http://www.stepac.com/), and the ExtendCastTM films from R.O.P. Ltd (http://www.rop-ltd.com/) have high water vapour permeability and maintain freshness while avoiding condensation and fogging.

Ethylene control

As climacteric fruits such as avocados, mangoes and bananas mature they produce a small amount of ethylene that eventually triggers ripening and the production of larger amounts of ethylene. This can then initiate ripening in other fruits potentially triggering a whole reefer or store room to ripen with potentially expensive consequences. Ethylene also initiates responses in non-climacteric fruits with research done in Australia in the 1990s showing that ethylene concentrations much lower than those previously thought necessary to trigger an effect can significantly reduce storage life and quality.

The ripening of climacteric fruits and the loss of storage life and quality of non-climacteric fruits can be prevented by removing ethylene from the atmosphere around them. To remove ethylene during transport, absorbers or filters are used in the reefers themselves or in the boxes or cartons, while larger air filtration systems are used in store rooms. The most common ingredient used in filters is potassium permanganate, usually impregnated on an inert carrier in granular or pellet form. The potassium permanganate oxidises ethylene to water and carbon dioxide, the purple permanganate being reduced to brown manganese oxide. It is a relatively simple, cheap technology, and there are many manufacturers of permanganate-based absorbers and air filtration systems. Other air treatment systems for cool rooms use ozone, which oxidises ethylene and has the added advantage that it also kills fungal spores and bacteria, and removes odours by oxidising volatile organic compounds.


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More recently ethylene adsorption by a patented combination of minerals and clays has been achieved and commercialised by It's Fresh (https://www.itsfresh.com/). Adsorption is a physical process rather than a chemical one like permanganate oxidation, and works at low temperatures. The material can be incorporated into thin sheets with no loose product that can spill. The ethylene adsorption capacity of the material is well characterized so that filter size can be tailored based on the ethylene production rate of the fruit and the pack size. It's Fresh filters are used commercially with non-climacteric fruits like berries, and climacteric fruits including peaches, nectarines, avocados, bananas, plums, golden kiwifruit, and cherries. The company is currently working on incorporating the technology directly into film and other packaging materials. The aim for this second generation It's Fresh technology is to reduce production costs and packaging waste by providing an alternative to the filter, and so giving growers a wider range of cost effective and recyclable options. Ethylene control technologies, like It's Fresh, are an opportunity to reduce waste in tropical fruit supply chains and potentially to bring to market new fruits that are particularly sensitive to ethylene and ripen quickly like cherimoya and other Annona fruits.

Filters though are only one way to control ethylene. A compound called 1-methylcyclopropene (1-MCP) works not by removing ethylene from the atmosphere, but by making fruits unresponsive to it. 1-MCP, discovered and developed in the early 1990s by researchers in the US, is perhaps the closest thing postharvest handling has had to a silver bullet. It is a gas that binds irreversibly to ethylene receptors in the fruit so that it cannot then respond to ethylene thus preventing ripening and other ethylene mediated changes. Following treatment most fruits resume normal ripening given time as new ethylene receptors are produced. 1-MCP is used commercially to extend the storage life and quality of apples in CA stores, and also with some other fruits such as avocados. Since its discovery the effects of 1-MCP on many fruits and vegetables have been studied, and it turns out that it is not quite the silver bullet it first appeared. Its use has to be optimised individually for each fruit. Factors such as variety, harvest maturity, 1-MCP concentration, and treatment temperature and duration all have to be considered. A method to extend the shelf-life of ripe bananas, called RipeLockTM from AgroFresh (https://www.agrofresh.com/), took many years to develop and combines a 1-MCP treatment, which must be carefully controlled and given at a precise ripeness stage, with specially developed modified atmosphere packaging. AgroFresh have also developed a 1-MCP treatment called HarvistaTM that can be sprayed on fruit before harvest, allowing growers to keep fruit on the tree longer, which can help with harvesting schedules. It is currently marketed for apples, pears and cherries. The development of HarvistaTM and the effort it took to get 1-MCP to work with bananas suggests to me that there may be other potential uses of 1-MCP for tropical fruits yet to be discovered. It would be very helpful to mango growers, for example, if HarvistaTM allowed them the option of keeping fruit on the tree longer thus extending the season.

Stopping the rot: pesticides

Fruits and vegetables spoil not only because they senesce, but also because of decay caused mostly by fungal and bacterial pathogens. Insect infestations, which are often of phytosanitary concern, are usually dealt with at source, for example, fruit fly in mangoes with hot water or vapour. Most postharvest fungal infections begin during production in the field, but remain quiescent and undetectable in immature fruits, only developing later as fruits ripen. The use of postharvest fungicides is therefore common and necessary to prevent spoilage.

Growers exporting to the EU face several problems with the choice of fungicides and other pesticides they can use. To be GlobalGAP compliant they must use only products that are authorised in their country and have a label-use for the crop they are growing. Pesticide authorisations are usually handled by agriculture or health ministries, but the time taken to make decisions is often very protracted, leaving growers without the tools they need. A further complication for growers of minor crops is whether a product has a label-use for their crop. This is usually dependent on whether the ag-chem companies have done the work needed to generate the data that would support such a use; and for minor crops they may well decide that the cost of doing so is not justified by the size of the market. This is also why there may be an EU maximum residue limit (MRL) for a given active ingredient on crops like bananas, avocados and pineapples, but not for minor crops like pitaya or passion fruit. COLEACP (https://www.coleacp.org/?lang=en) in particular over many years has supported growers of minor crops through research and technical assistance, and it is vital that this support continues.

Given that a product is authorised and has a label-use, growers must then use it so that any eventual residue is below the MRL set by the EU. This may further be complicated by retailer demands that any residue is no more than some fraction of the MRL. I think such arbitrary conditions are unfortunate and work against growers. Though MRLs are legal and not safety limits, they are determined with reference to toxicological data and typical dietary intake so that any benefit of such conditions to the consumer is debatable. Finally, the grower's choice of product may be further restricted by retailer pesticide lists that prohibit the use of certain active ingredients on fruit sold to them. This can leave growers with few options, particularly for postharvest use.

As the EU continues its review of active ingredients, growers must stay informed and make adjustments in response to changes in approvals and MRLs. Until recently thiabendazole was a commonly used postharvest fungicide, but following review its MRLs on a number of crops were amended. While substantive MRLs remain for citrus fruits, pome fruits, avocados, bananas and papayas, the MRL for mangoes was set at the analytical detection limit of 0.01 mg/kg, which caught the industry by surprise. Although Syngenta, the license holders for thiabendazole, are in the process of generating the data needed for a new MRL to be set, it is meanwhile impossible for mango growers to use it as a postharvest treatment. Pesticide legislation in producer countries can also change and that happened when the use of prochloraz, another common postharvest fungicide, was banned in Brazil in early 2016. Brazilian mango exporters to the EU were therefore left without two of the most common and widely used postharvest fungicides.

Faced with not being able to use products for regulatory reasons and with fewer products available, growers are forced to look for alternatives. Biopesticides and control agents are one option, but this is still a developing class of products and growers may face the same problem of a lack of authorisations and postharvest label uses. One common experience with biopesticides currently available is that they work well until disease pressure gets too high. Further development of effective biopesticides is needed, particularly ones that can be used postharvest. Of course the other option for growers is to use products that are approved in their country, but not for their crop. It certainly happens and often in a sophisticated way to avoid detection, though this is virtually impossible for postharvest applications as residues would nearly always be detectable. It is unfortunate when a grower is faced with making a decision like this, because the support is not there from national authorities or ag-chem companies. This is one area where the work of COLEACP and national research centres is absolutely vital in supporting growers.

Packaging

Packaging is an essential though increasingly costly supply chain component, protecting fruit from damage and bruising, keeping it fresh, dividing it up into manageable units, and making it easier to move and store. Walk through any distribution center and you will see a multitude of box sizes and designs. You will also see many research articles in which a box design has been improved to be stronger, have better airflow, or less board per box, which suggests to me that most boxes are not optimised.

Plastic packaging complements boxes and cartons, and does a fantastic job of protecting and keeping fruit fresh. Nevertheless concerns about plastic pollution and sustainability have prompted the industry to reduce plastic use wherever possible and use alternatives. Pulp and paper can replace many structural plastic items such as box liners, trays and punnets, but not others such as MAP bags or film lids on berry punnets. Where plastic cannot be replaced, it should at least be recyclable, biodegradable or compostable.

Packaging has also seen the introduction of sensors to create intelligent packaging that provides information about the condition of the pack contents. These include time-temperature indicators to signal temperature abuse, integrity indicators to signal when a pack such as a MAP bag has been breached, and freshness indicators to signal the end of shelf-life or the development of rots, moulds or other microbial contamination. Intelligent packaging has the potential to reduce waste through better stock control and a dynamic rather than static shelf-life. Nevertheless, with a move away from packaging for fruits and vegetables, and the low use of packaging anyway in some markets compared to others, it will be interesting to see whether intelligent packaging becomes an indispensable part of supply chains.

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An alternative to plastic packaging with a long history is edible coatings. These are used on citrus fruits, apples, pears, and pineapples variously to improve appearance, reduce moisture loss, preserve colour and texture, and prevent internal physiological disorders. A vast array of substances has been researched over the years including plant oils, gums, gels, waxes, starches, carbohydrates, proteins, alginates, beeswax, chitosan, shellac, sucrose esters, and cellulose derivatives. Researchers have also tried to incorporate antimicrobial agents into coatings to control fungal spoilage, and even nutriceuticals. The idea of coatings is straightforward and it is that the coating acts like a MAP bag creating a modified atmosphere inside the fruit and reducing moisture loss from it. Whilst coatings do indeed change the effective permeability of the fruit, they do not seem to work in exactly the same way as MAP, and have not become the ubiquitous replacement for plastic packaging that might have been hoped. Nevertheless, a new lipid and glycerolipid-based coating developed in the US by Apeel Sciences (https://apeelsciences.com/) claims to extend fruit shelf-life by reducing moisture loss and preventing oxygen diffusion into the fruit. The product is already being used on avocados, asparagus, citrus, cucumbers and apples, and was approved for use in the EU in June 2019. It is being trialled by European retailers and importers including Asda in the UK and Nature's Pride in the Netherlands, where Apeel avocados will be on sale in 2020. This exciting new product is already making an impact, and if it can be engineered for a wide range of fruits and vegetables it may finally deliver the promise of edible coatings to reduce waste and the use of plastic.

What next?

It is, or should be, astonishing that your breakfast smoothie can be made with a mango grown thousands of miles away in a place that you may never visit. That delicious mango is picked, kept fresh over several weeks, ripened and delivered to you ready to eat without it being damaged, bruised or going bad. It's amazing that it can be done at all, but can we do it better?

Regulation and certification

The integrity of our food systems is important to everyone. We want to be sure that our food is safe, that it's grown in a way that does not damage the environment, that it's sustainable, and that those working throughout the supply chain are properly paid and treated respectfully. Much of that is assured through voluntary standards, but the industry's self-regulation is fragmented and open to abuse, and this often works against the grower. There needs to be a consolidation of standards possibly through incorporation and merger, but more likely by the establishment of equivalency to minimise the audit burden on growers. We also need to make sure that auditing companies are above reproach in order to maintain industry and public confidence in our food supply and the way it's managed.

Sustainability and biodiversity

Sustainability is currently a major focus of the food debate, and despite the now well documented complexities, the ideas of local food and food miles are still part of it, with air-freighted produce being particularly criticised. Although there are sometimes good reasons for using it, can fruit that is currently air-freighted, because of a short storage life or advanced harvest maturity, be sea-freighted? For products that are air-freighted because of small volumes, is there a way to adapt a reefer to allow mixed loads that would enable small volume exports of several different fruits at once? Reefers within a reefer?

I haven't mentioned varietal development before now, because not very much is done for tropical fruits. It is difficult to justify the investment, private or public, for a minor crop breeding program. But for many crops there is considerable existing biodiversity that is not currently exploited. Often that is because a variety is perceived as difficult, but with a little ingenuity difficulties can be overcome. In Peru a handling protocol for the Edward variety was developed over several years to enable sea shipments at the start of the season before the first Kent. It certainly requires some adjustments to be made, not least by the importer, but it serves a purpose in the supply calendar at a time when Brazilian fruit is susceptible to internal browning. What other varieties are there, not only of mango, but of other fruits? Do they offer agronomic resilience as we confront and adapt to climate change? Do they offer the consumer a new and exciting experience?

Research and technology

Technological innovation through research is still needed, but scientists should focus on areas that make a difference, and that will almost invariably mean where there is a potential economic impact. It might not sound glamorous, but figuring out the optimum transport and storage temperatures for different mango varieties would potentially help save energy, take cost out of the supply chain and deliver a better quality fruit. Characterising the antioxidants present in different varieties is not, in my opinion, nearly as pressing.

A common feature of the last 20 years of postharvest technology development has been to make some of the dumb technologies that have been around for many years intelligent, or at least less dumb. We now have DCA, customised MAP, intelligent packaging, and the potential for an intelligent container. To those could we one day add robots that pick fruit according to size, maturity and defects? Could the intelligent container principle be extended into the distribution center? Could the principle of DCA be used to dynamically adjust ripening room conditions? Initiatives like these have tremendous potential to make supply chains more efficient and to reduce waste. Research should focus on overcoming remaining technical barriers - a small, remote ethylene sensor is a priority and a key piece of the puzzle - and most importantly on achieving it all at a viable cost. This latter challenge could well prove to be the most difficult of all.

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Consumer trends

Finally, what of the consumer? Consumer attitudes and behaviour towards issues can change very quickly as a result of media and social media exposure. The reaction against plastic packaging after stories were broadcast of the effects of ocean pollution on wildlife continues to drive change that demands a response from the postharvest community. The challenge is how to make sure that food loss and waste does not increase as plastic packaging is eliminated by retailers and shunned by consumers.

Consumers are used to cheap food, and for some price will always of necessity be the most important factor. But others are willing and indeed want to pay more for their food, because they are concerned that farmers and those who work in the supply chain be fairly paid. In response, Fairtrade (https://www.fairtrade.org.uk/) products, which have been available for almost 20 years now, have been joined by new options from recent initiatives such as BeFrank Bananas (https://befrank.world/en/) in the Netherlands, and C'est qui le Patron ?! (https://lamarque-duconsommateur.com/) in France, which perhaps reflects a strengthening of consumer sentiment and a feeling that Fairtrade is perhaps not fair enough.

So if consumers are willing to pay more for a fairer distribution of profits in the supply chain, are they also willing to support higher prices for other benefits such as less waste through the use of technology, more biodiversity on farms, or more sustainable, but less productive farming methods? Maybe, maybe not, but irrespective of how agriculture and horticulture look in future, what is certain is that we will still need to get bits of plants from growers to consumers fresh and without them going bad, and by and large we are very good at it ■

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