

A new system to prevent apple spoilage could save the UK's fresh produce industry up to £6 million per year.

The SafePod system helps to store fresh produce for long periods of time without it spoiling. Researchers from the University of Greenwich's Natural Resources Institute¹, led by Dr Debbie Rees and Dr Richard Colgan, used Agri-Tech Catalyst funding to develop SafePod², in partnership with Storage Control Systems Ltd and UK apple growers.

The research focused on improving the long-term storage of apples. Despite appearing only days old, apples grown in the UK are normally stored for anywhere between four and 12 months after harvest, before finally being transported to shops. To keep them fresh, growers store the fruit in controlled atmosphere (CA) rooms with a carefully regulated environment.

"A large proportion of apples harvested in the UK go into long-term storage," says Dr Rees. "If you want to store them for longer than two or three months, you have to store under controlled atmosphere."



A SafePod unit monitors stress and remaining storage life of apples in a commercial store. Image: Storage Control Systems Ltd

Insights from industry collaborators

Project partner Avalon Produce Ltd estimates that more than 250,000 tonnes of apples and pears are stored annually in the UK. They also estimate that increasingly stringent restrictions on the use of chemical preservatives are causing losses due to poor quality and disease of up to £15 million, making this an important time for the development of new long-term storage solutions.

Other collaborators on the BBSRC- and Innovate UK-funded project^{3,4} included Sainsbury's PLC, who provided links to apple growers and advised how SafePod could contribute commercially. Apple growers AC Goatham & Sons and Avalon Produce Ltd provided fruit and stores for the project, plus valuable advice on how growers would use the technology in practice. CA equipment manufacturers Storage Control Systems Ltd, inventors of the SafePod equipment, led SafePod's production.

Longer storage and spoilage prevention thanks to SafePod could save the UK fresh produce industry an estimated £3-6 million each year by reducing waste, says Avalon. In addition, SafePod could reduce the UK's reliance on imports. Currently only 31% of eating apples sold in the UK are home-grown⁵, but the SafePod could increase the availability of UK-grown fruit year-round. This could mean positive environmental impacts by reducing transport-related carbon emissions of fresh produce.

Too high, too low, just right

The key to long-term storage is to slow down how fast the apples use oxygen to prevent the fruit from ripening and going soft, but without using chemicals to do so.

IMPACT SUMMARY

A new system to reduce spoilage during long-term apple storage could save the fresh produce industry up to £6 million per year.

After harvest, apples are stored for up to 12 months in large controlled atmosphere stores. Low temperature, low oxygen and high CO₂ stop them over-ripening, but they can also spoil with insufficient oxygen.

The SafePod system, developed at the University of Greenwich's Natural Resources Institute, finds the perfect storage conditions by monitoring apples' respiration during storage. It detects if the apples become stressed and require more oxygen, and indicates when they have reached the end of their storage life. The system reduces waste via spoilage and allows apples to be stored for longer. SafePod could be used to improve long-term storage across a range of fresh produce.

SafePod was developed in collaboration with Sainsbury's PLC, AC Goatham & Sons, Avalon Produce Ltd, and Storage Control Systems Ltd. The system is now being trialled by apple growers in the UK and North America, with more than 200 units sold or leased in 2019.

This is achieved in CA storage by keeping oxygen levels and temperatures low, and sometimes raising CO₂ levels. However, too little oxygen can cause low-O₂ stress damage, where the fruit ferments and compounds such as ethanol and acetaldehyde are formed, which cause skin damage or flesh browning and an off-flavour. It is therefore vital that fruit is stored at the optimal oxygen level which prevents both over-ripening and low-O₂ damage.

"The apple industry has been looking for ways of picking up stress before the damage is done," says Rees.

"In order to store for longer, they're using lower and lower oxygen concentrations. The question is how far you can go without causing stress."

SafePod is helping to find this sweet spot. The system is a transparent chamber which holds four crates (75kg) of apples, with remotely controlled valves allowing it to be either sealed or exposed to the atmosphere within the surrounding environment. The SafePod is placed inside a large CA store filled with large wooden bins, each holding up to 300kg of apples.

When temporarily sealed, the SafePod monitors the atmosphere inside the container to track the fruit's metabolic status, comparing the rates of oxygen use and carbon dioxide production. In normal conditions the rates should be equal, but if the fruit becomes stressed and starts to ferment, carbon dioxide production rises. If this is detected, the whole store's conditions can be adjusted to prevent spoilage.

Alternatively, the SafePod can be sealed off from the store and the oxygen inside lowered further, to see how the apples respond. This allows the lowest safe oxygen level

Controlled Atmosphere Storage

Controlled atmosphere storage was pioneered in the 1920s by UK scientists at the Ditton Laboratory in Kent and at what later became the Institute of Food Research (now The Quadram Institute), one of BBSRC's strategically funded institutes.

By 1938, there were 200 commercial controlled atmosphere stores in the UK⁶. The recommended oxygen level for controlled atmosphere apple storage is roughly 1-2%, far lower than the 21% in the Earth's atmosphere.

to be found without risking damage to the whole store, ultimately increasing the amount of time for which the fruit can be stored. This is especially useful given that optimal storage conditions differ between varieties, as well as between batches of the same variety. In addition, a single batch may change during the storage season, and the SafePod makes it possible to adjust the storage conditions accordingly.

The team also discovered that tracking the apples' respiration rate can be used to predict when the fruit has reached the end of its storage life, at which point it can be transported to shops while still fresh. "Nobody before has been able to measure in such detail what's happening to apples in storage, and we see that it's as useful, if not more useful, than the original concept of finding the lowest possible oxygen concentration," explains Dr Rees.

Beyond the store

A variant of the SafePod is the LabPod, which can be used in the laboratory as a standalone chamber, and has extra controls to alter its internal atmosphere. Researchers



LabPod units (a variant of SafePod) being used to run trials on the stress responses of apples to different storage conditions.



The researchers focused on the UK's two main apple varieties, Gala and Braeburn, to develop their SafePod.

can use the LabPod to conduct experiments to find the optimal storage conditions for other produce. The team at Greenwich have used this to carry out trials on leeks, asparagus, and even daffodils. Their next focus will be on potato storage, to prevent spoilage from sprouting.

Storage Control Systems expect to lease more than 185 units in North America in 2019, with a revenue of approximately \$1M USD, and have sold a further 20 within the UK at a total value of £100k in the first half of 2019. They have also set up a website to collate information from different stores, creating an online community where apple growers can compare data between their own stores or with that of other growers.

REFERENCES

- 1 <https://www.nri.org/>
- 2 <http://www.storagecontrol.ltd/products/safepod-system/>
- 3 <https://gtr.ukri.org/projects?ref=BB%2F2FN004833%2F1>
- 4 <https://gtr.ukri.org/projects?ref=102276>
- 5 <https://quadram.ac.uk/spotlight/apple-facts/>
- 6 <https://quadram.ac.uk/about/history/>