Could chloroplast breakthrough unlock key to controlling fruit ripening in crops?

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Arabidopsis seedlings of three different genotypes grown in sectors. Wild-type plants (top) have a dark green color, reflecting their large chloroplasts with extensive thylakoid membrane networks; the ppi1 single mutant plants (bottom right) are pale yellow in color, due to the fact that their chloroplasts do not develop properly; the sp1 ppi1 double mutant (bottom left) has a much greener appearance than ppi1 and contain chloroplasts that are much more developed due to the absence of the SP1 protein. Credit: Paul Jarvis and Qihua Ling

Biologists may have unearthed the potential to manipulate the functions of chloroplasts, the parts of plant cells responsible for photosynthesis.

Researchers in the University of Leicester's Department of Biology

discovered that chloroplasts are affected by the ubiquitin proteasome system (UPS) – a process which causes the breakdown of unwanted proteins in cells, previously thought to only act on central parts of the cell.

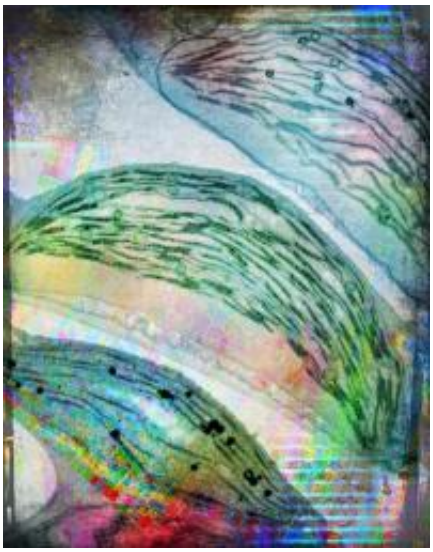
As a result, the researchers believe they may be able to use specific proteins to regulate the functions of chloroplasts – such as the conversion of chloroplasts into highly-pigmented chromoplasts during the ripening of fruit.

Their paper, Chloroplast Biogenesis is Regulated by Direct Action of the Ubiquitin-Proteasome System, is due to be published in the journal *Science* on Friday, November 2.

The paper identifies a gene (SP1) in the nuclei of plant cells that codes for a protein called a ubiquitin E3 ligase which is able to regulate chloroplast development through the UPS process.

The team are already investigating the potential for harnessing the SP1 gene in crop plants, for example to affect the ripening of fruits such as tomatoes, bell peppers and citrus.

The University's Enterprise & Business Development Office has filed a patent application with a view to developing practical applications for the research.



This shows chloroplasts from three different genotypes of *Arabidopsis thaliana*: a healthy wild-type chloroplast with an extensive thylakoid membrane network (center); a chloroplast from a ppi1 mutant plant which lacks the atToc33 protein (bottom); and a ppi1 plant with a second mutation in the SP1 gene (top). Chloroplasts from the sp1 ppi1 double mutant are much more developed than ppi1 single-mutant chloroplasts as the effects of atToc33's absence have been substantially suppressed by the absence of SP1. Credit: Mats and Paula Töpel

Professor Paul Jarvis, of the University's Department of Biology, has led the project since its inception in 2000.

He said: "Our work shows that the UPS also acts on subcellular compartments in plant cells called chloroplasts, which are responsible for the light-driven reactions of photosynthesis that power almost all life on Earth.

"Identification of this previously-unsuspected link between the UPS and chloroplasts constitutes a major breakthrough in biology, and may enable the manipulation of chloroplast functions in crops.

"It is incredible to get to this point – it has been a long journey. We have known for some time that this was going to be a big breakthrough."

The research has been funded by grants from the Biotechnology and Biological Sciences Research Council (BBSRC).

Professor Douglas Kell, Chief Executive of BBSRC, said: "To ensure that we have enough healthy, sustainable food for a growing population, we need to find a range of novel solutions to challenges such as improving crop yields and reducing food waste. This research highlights one of the many ways in which science can help.

"The ripening process can happen quickly, and it can take just a few days for a fruit or vegetable to be considered inedible. This unavoidable process means big losses to both farmers and consumers. This discovery brings us one step closer to greater control over ripening so that we have greater flexibility for farmers when supplying produces in the best condition."

Provided by University of Leicester