Salad days – tomatoes that last longer and still taste good

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Credit: University of Nottingham

The tomato (*Solanum lycopersicum*) is one of the most valuable fruit crops in the world with an annual global value in excess of $50bn. We eat so many they also play an important role in our diet providing valuable vitamins, minerals and health promoting phytochemicals. Plant breeders are working continuously to supply high yielding, better tasting, more nutritious and longer lasting tomato varieties, but some of the best tasting varieties soften rapidly and can have a short shelf life.

The precise mechanisms involved in tomato softening have remained a mystery until now. Research led by Graham Seymour, Professor of Plant Biotechnology in the School of Biosciences at The University of Nottingham, has identified a gene that encodes an enzyme which plays a crucial role in controlling softening of the tomato fruit.

The results, published today, Monday 25 July 2016, in the academic journal *Nature Biotechnology*, could pave the way for new varieties of better tasting tomatoes with improved postharvest life through conventional plant breeding.

The TomNet study was carried out by Professor Seymour in collaboration with Professor Paul Fraser at Royal Holloway, University of London. It was funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and Syngenta Seeds, a supplier of vegetable seeds to the global market.

Professor Seymour said: "To support the tomato industry and further improve consumer satisfaction with new tomato varieties, a major scientific goal has been to identify genes that allow the targeted control of fruit softening without impacting other aspects of ripening. Such work would permit excellent fruit flavour and colour development, combined with enhanced shelf life."

Major breakthrough in plant biology and fruit development

In the modern supply chain shelf life is critical. To reduce wastage this is often extended by developing hybrids that are bred to include natural mutations that slow the whole ripening process. But improving shelf life this way can often have a detrimental effect on flavour and colour.

The question of how the tomato fruit disassembles its cell walls and softens during ripening has perplexed researchers for over two decades. This research has found the key to uncoupling softening from the other aspects of fruit quality.

Professor Seymour and his team have identified a gene that encodes a pectate lyase which normally degrades the pectin in the tomato cell walls during ripening.

Professor Seymour said: "In laboratory experiments we have demonstrated that if this gene is turned off, the fruit soften much more slowly, but still show normal changes in colour and the accumulation of taste compounds such as acids, sugars and aroma volatiles. Natural variation exists in the levels of pectate lyase gene expression in wild relatives of cultivated tomato and these can be used for conventional breeding purposes. This discovery can provide a means to refine the control of fruit softening in modern tomato cultivars."

This latest discovery follows the sequencing of the tomato genome – research published in *Nature* in May 2012 and funded by BBSRC. Professor Seymour spearheaded the UK contribution to this international project with colleagues from Imperial College and the James Hutton Institute. The work also builds on BBSRC activities lead by Professor Fraser on advancing the tomato metabolome published in *Nature Scientific Reports*.

Dr Charles Baxter from Syngenta said: "This discovery has relevance for the development of new tomato varieties via conventional plant breeding and is a significant step forward in understanding processes involved in fruit development, allowing more refined control of this process in plant breeding."

Using conventional plant breeding, tomato wild species can be readily crossed with the cultivated tomato. One wild species, Solanum pennellii, has low levels of pectate lyase gene expression in the fruit. This genetic variation can be used to breed slow softening cultivated tomatoes.

Paul Fraser, Professor of Biochemistry at Royal Holloway said: "The study also shows how you can precisely alter fruit ripening properties without adverse effects on the chemical composition of the fruit. In this way the consumer traits such as taste, colour, and nutritional quality are not adversely affected and in some cases enhanced."

Professor Seymour said: "We already have a line harboring a very small section of the S. pennellii genome with the alternative form of the pectate lyase gene. This line can be crossed with an elite tomato variety. DNA sequence differences between the pectate lyase genes from the cultivated tomato and S. pennellii can then be used as markers to screen the progeny from this cross. Individuals can be selected that represent the elite line background, but also contain the S.pennellii variant of the gene. Then repeated backcrossing is undertaken to the elite line to fully recover this genetic background. The chosen lines are then self-pollinated a number of times to fix their genetic characteristics."

More information: Selman Uluisik et al. Genetic improvement of tomato by targeted control of fruit softening, *Nature Biotechnology* (2016). DOI: 10.1038/nbt.3602

Laura Perez-Fons et al. A genome-wide metabolomic resource for tomato fruit from Solanum pennellii, *Scientific Reports* (2014). DOI: 10.1038/srep03859

Shusei Sato et al. The tomato genome sequence provides insights into fleshy fruit evolution, *Nature* (2012). DOI: 10.1038/nature11119

Provided by University of Nottingham