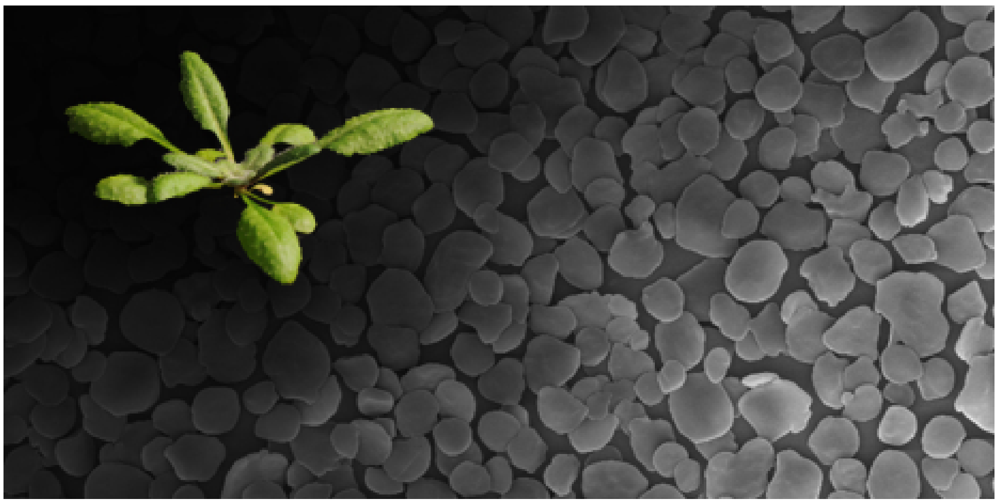
A taxi ride to starch granules

February 26 2015



Credit: ETH Zurich / from Seung D et al

Plant scientists at ETH have discovered a specific protein that significantly influences the formation of starch in plant cells. The findings may be useful in the food and packaging industries.

Starch acts as an energy reserve for plants and as an important source of carbohydrates in human and animal diets. Starch is also used in the food, construction, paper and textile industries. Amylose, an less digestible component of starch, serves as a binder and gelling agent in the food industry.

Despite the great importance of starch for plants, humans and industry alike, researchers do not understand completely how it is formed. The research group of Sam Zeeman, professor of plant biochemistry at ETH Zurich, has now found an important piece of the puzzle that throws more light on the structure of starch. The group has just published the findings in the scientific journal *PLOS Biology*.

New gene discovered

When the sun shines during the day, plants photosynthesise, making sugars from the carbon dioxide in the air, in order to fuel their metabolism. The excess sugar is converted into starch granules, which the plants store in the leaves and then tap into at night when they require energy but photosynthesis has been interrupted. Starch is by no means uniform, however, but instead made up of different components - largely amylopectin, a highly branched and easily digested polysaccharide, and to a lesser extent amylose, which is an essentially linear polysaccharide.

Until now, just one enzyme, sitting on the starch granules, was known to take part in the formation of amylose. In the absence of this little molecular machine, known as Granular Bound Starch Synthase (GBSS), plants cannot produce amylose.

Through a systematic search of the model plant thale cress (*Arabidopsis thaliana*) for other possible genes active in starch formation, Zeeman's researchers found one that is also involved in the creation of amylose. This gene encodes a protein that can bind temporarily to GBSS and starch, leading the former to its destination. As a result, the discoverer of the gene, David Seung, Zeeman's doctoral student, has called this molecule Protein Targeting to Starch (PTST).

Molecules are inter-dependent

The researchers conducted experiments with mutant plants in order to clarify the role of PTST. These mutations suppress the formation of PTST, leading to the complete absence of amylose in the mutant plants, although the total starch content is as high as that found in wild plants. As a result, the plant researchers concluded that *Arabidopsis* is necessarily dependent on PTST for the formation of amylose. To their surprise the researchers discovered that GBSS, the most common enzymes bound to plant starch granules, was hardly detectable in the mutant plants.

But how could they explain that? By marking the two proteins with fluorescent substances, the researchers finally solved this riddle. GBSS needs PTST because it is the taxi that transports GBSS to the starch granules. After collecting GBSS, PTST'parks' briefly on the surface of the emerging starch granules in order to unload its cargo. Afterwards, PTST detaches itself again from the starch granule, while GBSS gets on with the synthesis of amylose. In addition, the transport protein appears to be necessary for the stability of GBSS - without PTST and the binding to the starch granule, it is unstable.

Starch content as required?

The PTST protein not only appears in *Arabidopsis*, it is also conserved on an evolutionary basis. It came into being relatively early over the course of plant evolution, was preserved in the the diverging species and has changed very little since. As a result, it appears in many other plants, including various types of cereals. However, the role it plays there is still needs to be clarified, according to Zeeman. "This discovery nevertheless shows us a possible way in which we could regulate the amylose content in crops," explains Zeeman.

The new findings may one day be used to manufacture pure amylose for industrial applications. Amylose can be used as a gelling agent for sauces and puddings, and for the production of biodegradable packaging. As a result, the discovery has been protected with a patent application through ETH Transfer.

Seung discovered the function of PTST while working on his Doctoral thesis. Previously, the Australian received an ETH Excellence Scholarship, which allowed him to come to Zurich for his Master's programme. Now aided by a Heinz Imhof Fellowship, he is continuing his doctoral studies as part of a joint research initiative between ETH Zurich and the University of Stellenbosch in South Africa.

More information: *PLOS Biology*, 24 February 2014, DOI: 10.1371/journal.pbio.1002080

Provided by ETH Zurich