Genome-edited Potato Varieties for Enhanced Industrial and Nutritional Quality

Working group: Agrobiotechnology Laboratory, EEA Balcarce. Principal Investigator: Sergio Feingold.

Statement of problem:

Potatoes rank third among the most important food crops in the world. Consequently, the genetic improvement of this crop is vital. Two substantial quality traits in potato varieties are cold-induced sweetening and enzymatic browning in the tuber.

Cold-induced sweetening occurs due to low storage temperature, a normal postharvest practice. This produces sucrose conversion in reducing sugar. During the frying process, tubers produce a dark pigment and acrylamide, which is hazardous to health. Additionally, enzymatic browning is a consequence of oxidation that generates black spots on the tubers that are mishandled during harvest or transportation and the peeling and cutting processes. This generates economic losses due to rejects, lower consumer acceptance and loss of nutritional qualities.

Genome editing of potatoes entails a high degree of complexity due to its tetraploid genome and agamic reproduction. Under the current improvement system, varieties are unique combinations subject to improvement only by new crossbreeding and selection among thousands of progeny genotypes. Adopting CRISPR/Cas9 as a genome-editing tool substantially modifies the scheme to obtain varieties, since it allows incremental improvements on established and elite varieties in short times.

Technology Readiness Level:

Medium. Plants were generated with mutations aimed at the target genes, to validate the design of guidelines and constructs for both traits. Edited plants were generated for the gene that produces browning (PPO2) expressed in the tuber cultivar Desiree through Agrobacterium and transitorily in protoplasts by way of ribonucleoproteins. Tubers were produced from approximately 20 events, whose phenotypes are under assessment. We submitted a Prior Consultation Instance with CONABIA for the browning trait. Their response was that the resulting product would not be considered a GM vegetable organism.

Technology proposal:

The Agrobiotechnology laboratory at EEA Balcarce is working on potato varieties obtained through genome editing on genes from Invertases and Polyphenol oxidases, responsible for cold-induced sweetening and enzymatic browning, respectively. Gene silencing may result in the improvement of these traits.

It provides substantial advantages at different levels:

1- Functional value for consumers due to a product with higher organoleptic and nutritional quality (better frying and spotless potatoes) and reduction of products that are hazardous to health like acrylamide (carcinogenic potential) and antinutrients, like melanin. Additionally, preventing browning contributes in the accumulation of phenolic compounds that when incorporated in consumer diets helps to reduce the risk of degenerative, cardiovascular and metabolic diseases.

2- Commercial value for the potato processor, since storage at lower temperatures brings down storage costs, resulting in less use of anti-sprouting agents and fewer rejects due to browning.

3- Some of the potato varieties undergoing genome editing are proprietary to INTA. They are not available in the market, and this is a way to increase their value and presence.

Development requirements (testing, scale-up production, investment, etc.):

This project has been financed by the Technology Advancement Fund (FVT, as per the Spanish acronym) in its 2018 call, and funds from the PROCISUR Potato Consortium. Data are being generated to conduct the second stage Prior Consultation Instance (ICP, as per the Spanish acronym), in order to release edited plants for field assays, registration and reproduction, which will require additional investment. We are fine-tuning the regeneration and transitory expression of RNP in protoplasts in INTA and the potato consortium (PROCISUR) genotypes.