Gene-Edited Potato Varieties: From Laboratory Innovation to Agricultural and Industrial Application

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Potato (*Solanum tuberosum*) is the third most consumed food crop worldwide after rice and wheat, and represents a strategic crop for global food security. In Argentina, modern potato production is concentrated mainly in the provinces of Buenos Aires and Córdoba, where the leading cultivars are Spunta for fresh consumption and Atlantic for the potato chip industry. Despite its importance, potato breeding faces major challenges related to post-harvest quality, processing characteristics, environmental resilience, and disease resistance. Among the most critical industrial traits to improve are enzymatic browning and cold-induced sweetening, two physiological processes that strongly reduce both the quality of fresh tubers and processed products. On the agronomic side, breeding goals also include the development of cultivars with improved water-use efficiency and increased tolerance to major pathogens such as *Phytophthora infestans*, the causal agent of late blight. Traditional breeding of potato is particularly difficult due to its polyploid, highly heterozygous, and vegetatively propagated nature, which makes the process slow and labor-intensive, often requiring 10-15 years to release a new cultivar. In this context, advanced biotechnological tools such as CRISPR/Cas9-mediated genome editing provide a powerful alternative to accelerate the development of improved potato varieties with specific, well-defined traits. Our research group has been pioneering the application of genome editing to potato improvement, targeting genes associated with both quality and resilience. Our first achievement was the development of bruise-resistant potatoes derived from cv. Desiree. This was obtained through knockout (KO) of the *StPPO2* gene, which encodes a polyphenol oxidase enzyme responsible for enzymatic browning. We also generated cv. Atlantic lines resistant to cold-induced sweetening via KO of the vacuolar invertase gene (*StInvVac*), a key enzyme regulating the accumulation of reducing sugars during cold storage. In addition, KO of the *StCBP80* gene in cv. Spunta, a regulator within the abscisic acid (ABA) signaling pathway, resulted in plants with enhanced water-use efficiency. More recently, we are advancing the development of cv. Spunta potatoes edited simultaneously in *StPPO2* and *StInvVac*, aiming to combine resistance to both enzymatic browning and cold-induced sweetening within the same genetic background. Importantly, we are also focusing on increasing resistance to late blight by editing host susceptibility genes. Ongoing work is targeting *StDMR6* (Downy Mildew Resistance 6) and *StSR1* (Signal Responsive 1), two genes implicated in plant-pathogen interactions and previously validated as promising candidates for broad-spectrum disease resistance. Edited Spunta lines carrying modifications in these genes are currently under evaluation for their response to *P. infestans* infection. CONABIA determined that lines resistant to enzymatic browning, cold-induced sweetening, and improved water-use efficiency are not considered GMOs. In addition, the enzymatic browning resistant line and the cold-induced sweetening resistant line are currently under evaluation by INASE for registration as new varieties. Overall, our results demonstrate that genome editing can deliver potato products with superior industrial quality, reduced post-harvest losses, improved resilience, and enhanced disease resistance. These developments will benefit farmers, the food industry, and consumers, while positioning Argentina at the forefront of innovative, sustainable, and socially accepted crop biotechnology.