Genome Editing and Cultivar Choice for Nutrient-Dense Vegetables

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Abstract
Feeding Europe well in a warming world requires crops that deliver both high productivity and superior nutritional value.

Drawing on two complementary studies, we synthesize how cultivar selection and modern breeding—including CRISPR-based genome editing—can purposefully enhance health-promoting traits in greenhouse and other protected vegetable systems while preserving commercial performance. From this perspective, tailoring cultivars to defined environments stabilizes vitamin, mineral, pigment, and flavor profiles under managed light, temperature, CO_2, and nutrient regimes. Classical and advanced methods (hybrid breeding, backcrossing, marker-assisted selection, RILS (recombinant inbred lines), MAGIC populations (Multi-parent Advanced Generation Intercrosses)) remain foundational. Yet, innovations in phenomics, GWAS, and high-throughput genotyping accelerate the discovery of loci controlling bioactive compounds and anti-nutritional factors. Genome editing adds precision: CRISPR/Cas can directly modify alleles governing carotenoids, phenylpropanoids, bitterness, or postharvest traits without introducing unwanted linkage drag. Together, these strategies reduce breeding cycles, enhance quality improvements, and better align crops with market and public health objectives (Figure 1).

In conclusion, a dual approach—environment-tailored cultivar choice and targeted genome editing—offers the most efficient pathway to producing nutrient-dense vegetables at a commercial scale. Protected cultivation provides the phenotype stability breeders require, while modern genomics delivers speed and specificity. As multi-omics, rapid phenotyping, and edit-ready pangenomes converge, trait pyramiding for quality, resilience, and efficiency will move from experimental to routine practice in greenhouse vegetables.

The combined insights from these studies show that rapid, precise breeding for nutritional traits is already technically feasible and economically viable. This directly supports the UEAA's call for modernizing EU rules on genome editing—specifically, differentiating precision edits from transgenic GMOs. Such reform would enable the deployment of healthier, climate-resilient vegetables across Europe, while maintaining safety standards and competitiveness in a global market increasingly shaped by advanced breeding technologies.

Keywords: genome editing, CRISPR, protected cultivation, nutritional quality, cultivar choice

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