Table S1 Comparative Overview of Fruit Shape Regulation in Tomato, Chili Pepper, Cucumber, Peach, and Grape.

Aspect	Tomato	Chili Pepper	Cucumber	Peach	Grape
Overview of Fruit Shape Diversity	Tomato fruit shapes range from round, pear-shaped, to elongated and lobed forms. This diversity impacts consumer preference and marketability, with shape being controlled by multiple genes like *OVATE*, *SUN*, and *FAS*, along with hormonal pathways.	Chili peppers have diverse shapes, including screw, lantern, string, conical, and bullhorn peppers. These shapes are important for market grading. The Solanaceae family, shared with tomatoes, suggests a high degree of collinearity between genomes.	Cucumber fruit shapes vary from spherical to elongated forms. Changes in cell division, cell expansion, and carpel number influence shape, affecting market value and yield. Shapes are controlled by genetic and environmental factors, with QTLs such as FS1.2, FS2.1, and FS5.2 playing important roles.	Peach fruit shapes are primarily flat (doughnut-shaped) or round. Variations in chromosomal structures, particularly on chromosome 6, control these phenotypes. The distinction between flat and round types is a key target for breeding programs.	Grapes are cultivated for various uses (fresh, wine, drying). Fruit shape, controlled by multiple QTLs and hormonal pathways, impacts visual quality and market appeal. Research on grape fruit shape is less advanced than other crops but has identified key regulatory genes, including *VvSUN* and *SRK2A*.
QTL Mapping and GWAS Analysis	QTL mapping identified major loci like fs8.1 (elongation) on chromosome 8 and fas (locule number) on chromosome 11. lc controls locule number on chromosome 2. CRISPR/Cas9 validated gene interactions (e.g.,	A major QTL fs10 on chromosome 10 affects elongation, with *CaOFP20* as the candidate gene. fsi on chromosome 3 overlaps with other mapped QTLs. GWAS studies identified mutations in genes like TRM25 that	*CsCLV3* controls carpel number (chromosome 1), *CsSUN* regulates fruit elongation (chromosome 1), and *SF1* on chromosome 2 controls fruit length. FS5.2 (chromosome 5) modulates shape via auxin signaling, with	*PpCAD1* (chromosome 6) and a 1.67 Mb inversion regulate flat fruit formation. Structural variations and *LRRRLK* genes control shape variation. Major loci on chromosomes 5 and 6 impact longitudinal shape.	QTL mapping and GWAS identified 5 loci related to shape, including SRK2A on chromosome 7. Whole-genome studies identified 122 SNPs controlling shape, linked to genes like GATA 23-like, VIP1, and

	SlWUS-SlCLV3) affecting fruit size and shape.	regulate fruit shape.	*CsCRC* as a candidate gene. Mutants like sf1 and sf4 reveal more about shape control.	Genes like *PpOFP1* and PpTRM17 are part of the regulatory network affecting peach shape.	MADS-box 6. Ubiquitin ligases like F-box SKIP19 and RING finger 44 are involved in protein degradation affecting shape.
Key Genes and Functional Analysis	**-OVATE:** Inhibits growth, converts round to pear-shaped fruits via interaction with TRM [10-13,17]. **-SUN:** Promotes elongation through cell division, impacting auxin pathways [20]. **-FAS/LC:** Regulate locule number and fruit size.	**-CaOvate:** Homolog of OVATE, higher expression in round fruits. Silencing increases length [30]. **-CaOFP20:** Inhibits elongation; silencing results in elongated fruit [32]. **-TRM25:** Affects cell division and elongation.	**-CsFUL1A:** Regulates elongation via suppression of CsSUP and auxin transport proteins (PIN1, PIN7). Knockout elongates fruits [42]. **-CsTRM5:** Affects cell division and elongation [46]. **-SF2:** Regulates cytokinin metabolism and fruit length [41]. *CsCLV3*/*CsWUS* control carpel number.	**-PpCAD1:** Involved in cell death and cell expansion, associated with flat fruits [49]. **-PpOFP1/PpOFP2:** Affect fruit shape through interaction with PpTRM17, regulating vertical growth [54]. **-LRRRLK:** Controls stem cell population and fruit growth [60].	**-VvSUN**: A homolog of tomato *SUN*, regulates elongation via auxin pathways, localized to plasma membrane and chloroplasts [55, 58]. **-SRK2A**: Mutation affects protein function, influencing shape [56]. **-GATA 23-like**, **VIP1**, **MADS-box 6**: Regulatory transcription factors for fruit shape [65].
Future Directions for Research	Future research will explore interactions between *OVATE*, *SUN*, and other regulators. Understanding the	Further exploration of *CaOvate* and *CaOFP20* interactions, as well as the functional mechanisms behind	Future research will focus on downstream effectors of genes like *CsSUN* and *CsFUL1A*, and their interaction with	Research will focus on functional validation of *PpCAD1*, *PpOFP1*, and *LRRRLK* using CRISPR/Cas9.	Future studies will focus on functional validation of genes like *VvSUN* and *SRK2A*, along with exploring plant hormone

	molecular mechanisms of *FAS* and *LC* genes will improve breeding strategies for shape optimization.	identified QTLs and GWAS signals, will enhance breeding programs.	auxin and ethylene. Tools like CRISPR will be used for gene validation, especially for regulators like *CsCRC* and *CsTRM5*, along with understanding environmental impacts on shape.	Understanding chromosomal structural variations (e.g., 1.67 Mb inversion) and their effect on gene expression will improve breeding programs for fruit shape optimization.	interactions. Research will aim to improve fruit shape for market appeal using gene editing and advanced breeding tools.