Tomato *high pigment* Mutants and their Central Role in Enhancing Fruit Pigmentation and Functional Quality

Ilan Levin, Yaakov Tadmor, Michal Oren-Shamir, Moshe Reuveni, Ayala Meir, Rinat Ovadia, Maya Sapir, Igor Kolotilin, Dalia Evenor, Sahadia Nahon, Haviva Shlomo, Lea Chen, and Amir Bootbool*
Institute of Plant Sciences, the Volcani Center, P.O.Box 6, Bet Dagan, Israel 50250

Phenotypes of the tomato (*S. lycopersicum*) *high pigment* (*hp*) mutants are caused by lesions in genes encoding DEETIOLATED1 (*hp-2*, *hp-2$_j$*, *hp-2$_{dg}$*) and UV-DAMAGED DNA BINDING PROTEIN 1 (*hp-1*, *hp-1$_w$*), proteins that regulate of light-signaling. Homozygous *hp* plants display a plethora of developmental and metabolic phenotypes in comparison to their normal isogenic counterparts, but they are best known for their increased levels of fruit carotenoids, primarily lycopene. Moreover, recent studies generalize earlier ones showing that fruits harvested from *hp* mutant plants are also characterized by significantly higher levels of other plastid-accumulating phytonutrients, such as: vitamins C and E. Further, these fruits are also enriched with certain flavonoid compounds, also known for their functional, or health-promoting, value. Commutatively, these results highlight a strong link between light-signaling and over-production of fruit phytonutrients. Results recently obtained show that *hp* mutants, in combination with other mutant genes, can enhance fruit pigmentation and functional quality in a morethan-additive manner. We have recently demonstrated this interaction with *ANTHOCYANIN FRUIT* (*AFT*, formerly *AF*) mutants. *AFT* mutant plants were originally characterized as sharing excess anthocyanins, functional flavonoid metabolites, in fruits and vegetative tissues. We have recently found that: **(1)** *AFT* fruits are characterized by significantly higher levels of the flavonols quercetin and kaempherol, in addition to anthocyanins; and **(2)** Double homozygous *AFT/AFT hp-1/hp-1* plants display a morethan additive effect of on the production of the anthocyanins delphinidin, petunidin and malvidin and the flavonols quercetin and kaempherol in fruits. This effect was strongly manifested by ~24-fold average increase in fruit anthocyanin content in the double mutants in comparison to the cumulative levels of their parental lines, thus enhancing their functional and pigmentation qualities. These results are in agreement with an additional study showing a strong interaction between *AFT* and both *hp-1$_w$* and *hp-2$_j$* and between each of the latter two mutations and the recessive *atroviolacium* (*atv*) mutation. Mutant *HP* genes share adverse pleiotropic effects, such as slow germination and seedling growth, seedling mortality, inferior leaf coverage, brittle stems, low yield, reduced total acidity and soluble solids content, high sensitivity to various pathogens and premature defoliation, which have prohibited widespread commercial use of these genes. However, their central role in enhancing fruit pigmentation and functional quality, demonstrated herein, justifies extended breeding efforts to reduce these negative effects. Such efforts have already led to the development of several "lycopene rich" tomato cultivars carrying *hp* mutations that are being successfully used in production.