The New Jersey Fresh Market Tomato Breeding Program: Genetics and Breeding of Flavor

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The good old days of local production, vine-ripe harvest, and supermarket buyers caring about flavor were replaced during the 1960s and 70s by distant production, gas-green harvests, and supermarket chain buyers caring only about price and shelf life. Consumers were never consulted about the sacrifice of fruit quality in return for cost consciousness, and a backlash has driven a resurgence of vine-ripe flavor as a desirable attribute of fresh market tomatoes. Contemporary varieties have been pushed in the direction of durability and shelf-life, and while they taste better if left on the vine to ripen, most never achieve the standard of the consumer's memories. Part of the reason is that ripening inhibition genes are used extensively to arrest the softening process, so red tomatoes will remain firm for longer periods of time during distribution and display. Another large part of the reason is because consumers also don't have a very realistic recollection of "old time tomato flavor".

Can a better flavor profile be attained by simply growing heirloom tomato varieties? The overall results of an extensive study on consumer perception of heirloom tomato varieties conducted at Rutgers lead to the conclusion that certain of them exhibit highly favorable flavor profiles. Many heirloom varieties are not genetically pure, however, and are known to exist in a plethora of selections or strains. As a group, heirloom varieties are not well-adapted to modern vegetable farming. Yields and fruit uniformity are greatly reduced as compared to contemporary hybrids, and the smaller harvests are much more prone to damage during packing, distribution, and display. Heirloom varieties, therefore, are more adapted to a direct-marketing business than to wholesale operations.

Is it possible to tread a genetic middle ground between contemporary and heirloom varieties? Many fresh market tomato products have appeared in retail venues that exhibit fruit characteristics common to heirloom varieties, including better flavor. These same varieties appear to have horticultural attributes more akin to contemporary than to indeterminate heirlooms. Since these products are not available from seed companies, and remain the proprietary property of growers, it is not clear what the genetic origin is, but it is reasonable to presume that these varieties were derived from heirloom x contemporary crosses.

During the mid 1960s, Dr. Bernie Pollack of Rutgers University introduced the new hybrid variety 'Ramapo'. This variety curried favor with home gardeners due to its sweet, tart flavor, and they continued to request the seed from Rutgers long after it disappeared from catalogs in the 1970s. What is so special about the flavor of 'Ramapo'? Following several years of scientific consumer taste-testing, it is clear that nothing is very clear at all. Different consumers value different aspects of tomato flavor in different ways, so it is not surprising that no single variety always rises to the top. In general, 'Ramapo' always fares well among the competition, but other varieties such as 'BHN 589' were rated even higher.

The scientific literature has much information on determination of flavor in tomato. The primary factors are sugars and acids that condition fruit sweetness and tartness. Tomato flavor is much more complex, affected by hundreds of organic compounds collectively known as volatiles, since they readily transform from liquid to gaseous phase. The genetic basis of variation in fruit sugars, or soluble solids, is well established in processing tomatoes to be controlled by many genes with small individual effects. The genetics of fruit organic acids is not as well understood.

'Ramapo' is a relatively acidic tomato. The pH level is very low as compared with other fresh market tomatoes, and the concentration of dissolved organic acids, as measured by titration (titratable acidity or TA), is relatively high. In contrast, fruit sugars, or soluble solids (SS), are in the intermediate range as compared to other fresh market tomato varieties. Fruit acidity and soluble solids have been observed to vary tremendously with growing conditions and plant age, however.

Since 'Ramapo' is a hybrid variety, it is derived from the cross of two inbred parent lines, in this case 'KCA' and 'Abbie', that were originally identified by Dr. Pollack. TA and SS were found to be similar in 'KCA' as compared with 'Ramapo', and different in 'Abbie'. An examination of the segregation of TA and SS in F_2 and backcross populations during Summer 2008 showed that TA has a simple basis of inheritance, probably a single dominant gene, while the inheritance of SS is more complex. Thus, it may be possible through crosses with 'KCA' to transfer high TA to many different genetic backgrounds.

The Rutgers tomato breeding program currently consists of two full generations per year. During the winter, crosses between lines carrying desirable genes are made in greenhouses at RAREC. Over the summer production seasons, breeding nurseries are grown on RAREC test sites to identify populations that have the best horticultural promise, in combination with fruit quality. A better overall balance of fruit flavor, texture, and color with horticultural plant type is sought through breeding, and possibly molecular biology. Populations that exhibit high flavor profiles, intermediate firmness, and high lycopene in combination with determinate, early plant types will be selected. Thus, it will be possible to introduce better tasting, high-yielding 'Jersey' tomatoes into retail supermarket chains.