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USDA 97L63, 97L66, and 97L97: Tomato Breeding Lines with High Fruit Beta-carotene Content

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Three new tomato (*Lycopersicon esculentum* Mill.) breeding lines, 97L63, 97L66, and 97L97, have been developed and released by the Agricultural Research Service, U.S. Dept. of Agriculture (USDA). These lines produce fruit with high beta-carotene content, that are midseason in maturity, and are best suited for processing applications.

Many investigations have examined the relationship between vegetables, fruit, and human health (Steinmetz and Potter, 1996). These new releases of tomato breeding lines were developed as value-added germplasm with enriched phytonutrient content. Beta-carotene, like other carotenoids, is an antioxidant and may protect against free radical damage. Beta-carotene can also be metabolized to vitamin A and is an essential nutrient for mammals, since it cannot be synthesized within the body. Ross (1998) and Tee (1992) have reviewed the roles that beta-carotene and vitamin A play in growth and reproduction and mortality and morbidity from infectious diseases. Lines 97L63, 97L66, and 97L97 represent the first in a series of intended releases from the USDA breeding program of tomato germplasm with enhanced fruit carotenoid content and nutritive value.

Origin

USDA 97L63, 97L66, and 97L97 were derived from an initial interspecific cross between *L. esculentum* cv. Floradade and the wild tomato relative *L. cheesmanii* f. *minor* (Hook f.) C.H. Mull, accession LA317 (Fig. 1). LA317 was the donor parent for the dominant *Beta* (*B*) gene (Lincoln and Porter, 1950; Zhang and Stommel, 2000), which conditions accumulation of high beta-carotene levels relative to other colored carotenoids in ripe fruit. Consistent with expression of *B*, beta-carotene is accumulated at the expense of lycopene. The dominant form of *B* is influenced by a linked modifier gene Mo_B. In the presence of the homozygous recessive form of the allele, Mo_B Mo_B, beta-carotene represents >90% of the total carotenes. Expression of the dominant Mo_B^+ form of the modifier allele reduces beta-carotene content to 50% to 60% and increases lycopene content to <50% of the total carotenoids, resulting in red-orange fruit. Molecular markers linked to the *B* and Mo_B genes have been developed (Zhang and Stommel, 2000). Lines 97L63, 97L66, and 97L97 are homozygous *BB* Mo_B Mo_B, resulting in orange-pigmented fruit. Lines 97L63 and 97L66 are bulks of selected plants in the F_5 generation of the fourth backcross to the processing type tomato cultivar FM6203 (Fig. 1). Line 97L97 is an F_5 bulk from the second backcross to the processing cultivar Ohio 8245 (Berry, 1991).

Description

Lines 97L63 and 97L66 have a compact, determinate (*sp* gene) growth habit with concentrated fruit set. Plants are adapted for production in California (Davis and Stockton, Calif.) and the Eastern (Beltsville, Md.) and Midwestern (Bowling Green, Ohio) United States and have good canopy cover. Fruit beta-carotene content averaged 57.6 and 55.1 $\mu g \cdot g^{-1}$ tissue fresh weight for 97L63 and 97L66, respectively, ≈29 times the concentration present in the recurrent parent FM6203 (Table 1). Little difference in beta-carotene content was evident between the Beltsville and Stockton locations (data not shown). Fruit are firm, crack-resistant, blocky-round shaped, have two to three locules, ripen uniformly (*u*), and have jointed pedicels (Fig. 2 A and B, respectively). Fruit weight of 97L63 averaged 80.0 g, comparable with that of FM6203 (Table 1); fruit of 97L66 were smaller, but not significantly different from FM6203. Fruit soluble solids content averaged 5.0% and 5.4% for 97L63 and 97L66, respectively, 11% and 20% higher than that for FM6203 (Table 1). Increased soluble solids content in these breeding lines may be attributed to the transfer of favorable genes from the wild donor parent *L. cheesmanii* f. *minor*; some accessions have been identified with 12% to 15% soluble solids (Garvey and Hewitt, 1984).

Line 97L97 is well adapted for eastern and midwestern production. Fruit set is concentrated. Fruit beta-carotene content averaged 55.5 $\mu g \cdot g^{-1}$ tissue fresh weight, ≈16 times the content in the recurrent parent Ohio 8245 (Table 1). Fruit are firm, pear-shaped, have two to three locules, ripen uniformly (*u*), and have jointless pedicels (*j2*) (Fig. 2C). Fruit weight of 97L97 averaged 57.7 g, comparable with that of the recurrent parent. Fruit soluble solids content averaged 4.4%, similar to that of Ohio 8245 (Table 1). Line 97L97 tended to be semideterminate under California growing conditions. (Plants with delayed termination of the main stem, thus more inflorescences, are termed semideterminate.) Semideterminate growth habit is controlled by a recessive gene, *sdt*, and may not be expressed under some environmental conditions (Elkind et al., 1991). Genetic variation in the number of inflorescences on the main shoot may also occur in determinate genotypes, however, resulting from the timing of formation of the final two inflorescences (Cuartero and Cubero, 1985). Additional analysis is required to distinguish between these genotypes in 97L97.

Use

Lines 97L63, 97L66, and 97L97 are best suited for development of cultivars for processing applications, including juice or sauce production. Processed product of high beta-carotene-containing tomato fruit may be utilized alone or in blends for juice and sauce

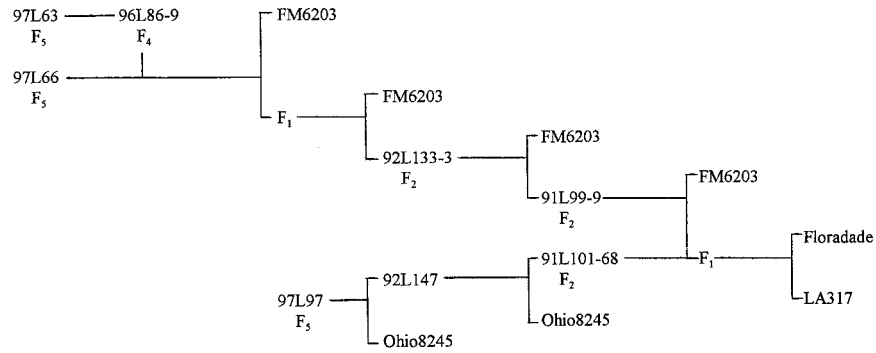

Fig. 1. Pedigrees of USDA 97L63, 97L66, and 97L97.

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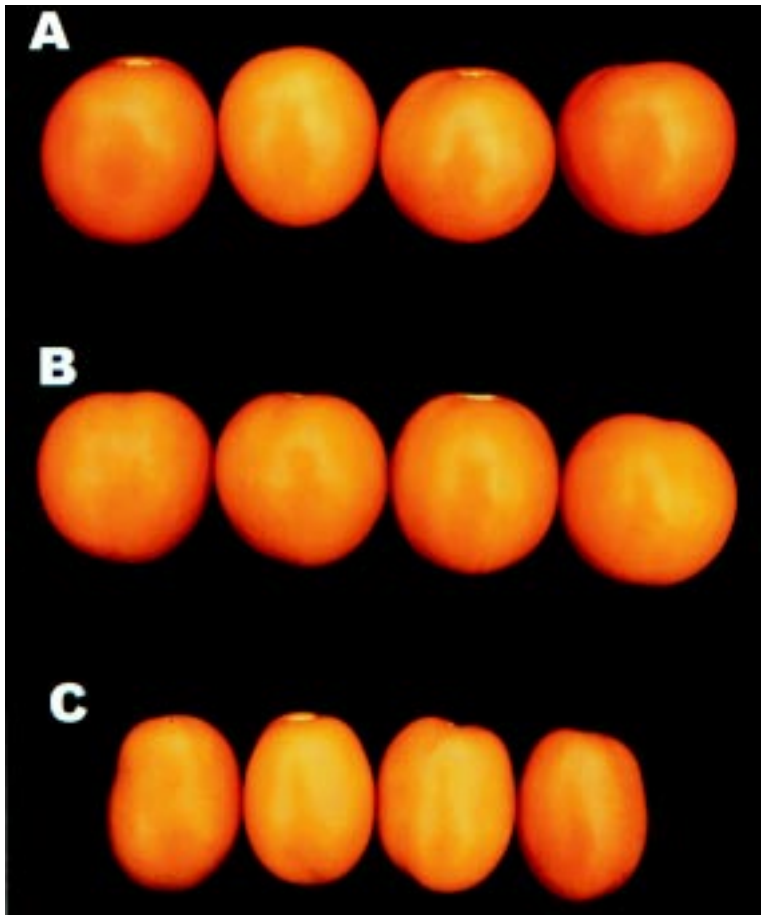

Fig. 2. Fruit of USDA tomato breeding lines with high fruit beta-carotene content: (**A**) 97L63, (**B**) 97L66, and (**C**) 97L97.

Table 1. Beta-carotene content, percentage of soluble solids, and fruit weight (mean ± SE) of tomato breeding lines USDA 97L63, 97L66, and 97L97 and commercial cultivars in trials at Beltsville, Md.

Line	Beta-carotene ($\mu g \cdot g^{-1}$ FW)[z]	Soluble solids (%)[z]	Wt/fruit (g)[y]
97L63	57.6 ± 5.7 a[x]	5.0 ± 0.1 b	80.0 ± 2.7 a
97L66	55.1 ± 5.9 a	5.4 ± 0.1 a	72.7 ± 1.8 a
97L97	55.5 ± 5.7 a	4.4 ± 0.2 c	57.7 ± 1.5 b
FM6203	1.9 ± 0.2 b	4.5 ± 0.2 c	82.3 ± 6.2 a
Ohio 8245	3.4 ± 0.6 b	4.2 ± 0.1 c	60.4 ± 2.9 b

[z]Data represents means for beta carotene and soluble solids in 12 bulked samples from single plants in one 12-plant plot. Beta carotene content determined as described by Stommel and Haynes (1994).
[y]Data represents means for fruit weight in 24 bulked samples from single plants in duplicate 12-plant plots.
[x]Mean separation within columns by LSD, $P \leq 0.05$.

production. Ripe fruit may also be utilized for diced product or fresh saladette applications. Their combination of desirable plant and fruit characteristics make them a desirable source of the *Beta* gene to allow breeders to develop new cultivars with high beta-carotene content. USDA requests that appropriate recognition be made if this germplasm contributes to the development of a new breeding line or cultivar.

Availability

USDA 97L63, 97L66, and 97L97 are breeding line releases. Small samples of seed are available for professional trial and breeding purposes upon written request to John R. Stommel, U.S. Dept. of Agriculture, Agricultural Research Service, Vegetable Laboratory, B-010A, BARC-West, 10300 Baltimore Ave., Beltsville, MD 20705.

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