Processing Tomato Germplasm with Improved Fruit Soluble Solids Content

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Five processing tomato (*Lycopersicon esculentum* Mill.) breeding lines with improved soluble solids content (SSC or °Brix) relative to 'UC 204B' were developed by introgression from a high-SSC line, LA 528 (*L. cheesmanii* Riley), to a cultivated processing tomato background by use of inbred backcross breeding. In field trials over several locations and years, these breeding lines exhibited significantly higher SSC than the recurrent parent, 'UC 204B', and had red fruit not significantly smaller than 'Peto 95-43', a smaller-fruited processing cultivar. These lines are available for use as breeding germplasm or in studies on SSC.

Origin

The inbred backcross (IBC) breeding method (Bliss, 1981) was used to develop a population of 106 IBC lines from *L. esculentum* 'UC 204B' × *L. cheesmanii* LA 528 (Fig. 1). 'UC 204B' is an open-pollinated (OP) commercial processing tomato cultivar with moderate SSC (5.0% to 5.2%; Table 1). 'UC 204B' was chosen as the recurrent parent since it represented a widely grown commercial OP cultivar when this project was initiated in 1988; most other commonly used cultivars are F₁ hybrids. LA 528 is a wild species accession with small, yellow fruit and was chosen for its extremely high SSC, 11.0% to 15.1%. Many accessions of this species have high SSC (Garvey and Hewitt, 1984). LA 528 seed was obtained from the C.M. Rick Tomato Genetic Resource Center, Dept. of Vegetable Crops, Univ. of California, Davis. The IBC lines were advanced by single-seed descent to the BC₂S₃ and BC₃S₂ generations (Fig. 1). Seed from subsequent selfing generations were bulked. No intentional selection was imposed during the creation and subsequent field evaluation of the IBC population.

All 106 IBC lines and standard cultivars were tested in replicated field experiments using a randomized complete-block design.

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Four blocks were included at each of three northern California field locations in 1991 and 1992. Commercial processing tomato cultivars (OP 'Peto 95-43', 'Hunt 100', 'UC 204B', and F₁ hybrid 'FM 785') were included in the trials as standards, with 'Peto 95-43' representing the lower limit for commercially acceptable fruit size. A sample of 25 to 30 fruit was collected from each plot consisting of eight plants. The fruit were bulked and quantitatively analyzed for fruit SSC, pH, and fruit weight (grams/20 fruit). Subjective scores also were recorded for fruit color, yield, plant architecture, and other horticultural traits (e.g., foliage cover, fruit set). The SAS statistical program (SAS Institute, 1988) was used to conduct analyses of variance and mean separations. A total of 46 IBC lines exhibited a

significantly higher SSC than the recurrent parent 'UC 204B'. Initially, 14 of these 46 lines also had acceptable fruit size, pH, and horticultural traits (Triano and St. Clair, 1993). These 14 lines were subjected to a third year of replicated field testing at three locations in 1993. Additionally, 12 of these lines were replicated at a single location in 1994 for observation and seed increase. Five lines with consistently improved SSC relative to 'UC 204B' and acceptable fruit size, pH, and color were selected for release as breeding lines.

Description and performance

The five IBC lines all exhibited acceptable plant architecture, determinate growth, foliage cover, fruit set, and fruit quality (i.e., pH, weight, color), although the lines still exhibit some variation due to limited selfing and bulked seed during later-selfing generations. The lines have mean SSC ranging from 5.47% to 5.83% (Table 1). In comparison, the mean SSC for 'UC 204B' was 5.10%, significantly less than the selected lines (Table 2). The presence of year × location interactions required mean separations by year and location (Table 2). Fruit pH for the selected lines was 4.19 ± 0.09, a pH equal to or lower than any of the standard cultivars. Fruit weights were higher than, or not significantly different from, the small-fruited 'Peto 95-43', indicating that fruit size was commercially acceptable.

Recurrent Parent

Donor Parent (high soluble solids)

Fig. 1. Pedigree of 106 IBC lines from *Lycopersicon esculentum* 'UC 204B' × *L. cheesmanii* LA 528. The ⊗ denotes selfing by single-seed descent.

Table 1. Tomato fruit soluble solids content (SSC) measured over 3 years of replicated field trials in California. Each inbred backcross (IBC) line and cultivar was replicated four times at each of three field locations. The last number in the IBC line name indicates the backcross generation (BC₂ or BC₃). See Table 2 for mean separations by year and location.

IBC lines and standards	SSC range measured over 3 years (%) ²	Mean SSC over years and locations (%)
89084-3	5.18–5.70	5.53
89109-3	5.10–5.95	5.52
89111-2	5.35–6.90	5.83
89113-3	5.35–6.25	5.77
89114-3	4.95–6.00	5.47
UC 204B	4.77–5.54	5.13
Hunt 100	4.79–5.95	5.26
FM 785	5.04–6.40	5.57
Peto 95-43	4.35–5.33	4.74
<i>Lycopersicon cheesmanii</i> LA 528	11.00–15.10 ³	13.25

²Values are location means within years.

³Measurements from greenhouse-grown material due to daylength requirements for fruiting.

Table 2. Dunnett's *t* tests by location within years for mean soluble solids content (SSC, %) of lines. Asterisks indicate a significant difference ($\alpha=0.05$) between the means compared. Mean comparisons were not made with the standard cultivars Hunt 100 and Peto 95-43 because they both have lower SSC and were used primarily as horticultural standards. Year $\times$ location interactions were detected by analysis of variance, which precluded the separation of grand means in Table 1.

Pairwise comparisons	Location 1			Location 2			Location 3		
	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3	Year 1	Year 2	Year 3
89084-3 : UC 204B		*				*	*		*
	5.48:5.11	5.35:4.81	5.70:5.33	5.70:5.42	5.93:5.54	5.35:4.89	5.70:5.02	5.18:5.01	5.38:4.77
89109-3 : UC 204B	*					*			*
	5.83:5.11	5.10:4.81	5.35:5.33	5.95:5.42	5.85:5.54	5.45:4.89	5.50:5.02	5.28:5.01	5.38:4.77
89111-2 : UC 204B	*	*		*	*	*	*		*
	6.08:5.11	5.40:4.81	5.50:5.33	6.90:5.42	6.35:5.54	5.40:4.89	6.00:5.02	5.40:5.01	5.45:4.77
89113-3 : UC 204B	*	*	*	*	*	*		*	*
	5.70:5.11	5.58:4.81	6.03:5.33	6.25:5.42	6.05:5.54	5.68:4.89	5.35:5.02	5.73:5.01	5.58:4.77
89114-3 : UC 204B					*		*		*
	5.50:5.11	5.23:4.81	5.60:5.33	5.78:5.42	6.00:5.54	5.23:4.89	5.65:5.02	5.28:5.01	4.95:4.77
89084-3 : FM 785									
	5.48:5.65	5.35:5.47	5.70:6.40	5.70:5.58	5.93:5.60	5.35:5.45	5.70:6.40	5.18:5.04	5.38:5.25
89109-3 : FM 785			*						
	5.83:5.65	5.10:5.47	5.35:6.40	5.95:5.58	5.85:5.60	5.45:5.45	5.50:6.40	5.28:5.04	5.38:5.25
89111-2 : FM 785	*		*	*					
	6.08:5.65	5.40:5.47	5.50:6.40	6.90:5.58	6.35:5.60	5.40:5.45	6.00:6.40	5.40:5.04	5.45:5.25
89113-3 : FM 785		*				*			
	5.70:5.65	5.58:5.47	6.03:6.40	6.25:5.58	6.05:5.60	5.68:5.45	5.35:6.40	5.73:5.04	5.58:5.25
89114-3 : FM 785			*						
	5.50:5.65	5.23:5.47	5.60:6.40	5.78:5.58	6.00:5.60	5.23:5.45	5.65:6.40	5.28:5.04	4.95:5.25

Two of the five IBC lines exhibited SSC significantly higher than 'FM 785', a high-SSC F_1 hybrid cultivar (Table 2). It is likely that the five IBC lines contain *L. cheesmanii* alleles for improved SSC not found in 'FM 785' or other high-solids commercial cultivars bred from *L. esculentum* germplasm. All five IBC lines are being released to increase the probability of including most or all of the major alleles for improved SSC present within the IBC population; some of these alleles may not be represented in the top two performing IBC lines.

To facilitate marker-assisted selection for fruit quality traits, DNA samples from each line have been analyzed using restriction fragment length polymorphisms (RFLPs) to locate quantitative trait loci (QTL) associated with SSC, pH, and fruit weight. The RFLP polymorphism difference between *L. esculentum*

and *L. cheesmanii* is 30% to 35%, much higher than within *L. esculentum* (Williams and St. Clair, 1993), permitting QTL mapping and the use of marker-assisted selection in breeding. The RFLP clones used in these analyses have been supplied by S. Tanksley, Cornell Univ., Ithaca, N.Y., to whom inquiries regarding clone acquisition should be directed. Information on markers linked to QTL will be made available upon request.

Seed availability

Small samples of seed are available for all five selected IBC lines. Seed requests should be sent to Dina St. Clair, Dept. of Vegetable Crops, Univ. of California, Davis, CA 95616-8746. Seed recipients are asked to give appropriate recognition of the germplasm source if

it is used in research or in developing a new germplasm or cultivar.

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