Screening the Cucumber Germplasm Collection for Fruit Storage Ability

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Abstract. All available cucumber (*Cucumis sativus* L.) cultigens were tested for combining ability for fruit storage ability by crossing them with the gynococious inbred Gy 14. Fruit weight and firmness were measured before and after storage, and fruits were rated for water loss after storage. The cultigens with the lowest percentage of fruit weight loss during storage were PI 172839, PI 344067, PI 264667, PI 171612, PI 339245, PI 220171, PI 279469, and PI 368550; those with the lowest percentage of loss in fruit firmness were PI 379284, PI 339241, PI 414159, PI 422177, 'Regal', PI 109483, 'Addis', PI 285603, PI 257486, and 'Calypso'. The cultigens demonstrating the least fruit shriveling were 'Dasher II', 'Sprint 440', 'Texas Long', PI 390255, PI 432870, 'Pacer', PI 419078, PI 390247, PI 321011, and PI 414158. The 10 best cultigens from the initial screening study, along with the four worst cultigens and six checks, were retested directly (not as F₁ progeny) for fruit keeping ability in two storage conditions and at two harvest dates. No significant differences were detected between the two harvest dates and storage conditions.

The cucumber fruit is botanically classified as a pepo (an inferior berry) and is nonclimacteric (Biale and Young, 1981). Because cucumbers are often harvested and stored for several weeks before use by the consumer, keeping ability is an important trait. According to Buescher (1986), the fruits can be stored for 1 or 2 weeks under optimal conditions [i.e., 4 °C, 100% relative humidity (RH), and 1% O₂ and 30% CO₂] without loss of quality. Both environmental and genetic factors are involved in keeping ability; a large genetic component is the fruit type. Commercial types of cucumbers include american pickling (processing), european pickling, american slicing (fresh market), european greenhouse (parthenocarpic), oriental trellis (burpless), middleeastern cucumbers (Beit Alpha), and schaligurken (german pickling) (Wehner and Horton, 1986).

Cucumber breeders have developed cultivars that are white-spined rather than black-spined because of the linkage or pleiotropy between genes *B* and *R* (Hutchins, 1940). Large, immature fruits that would be green in

the northern parts of the United States turn yellow to orange in the southern states if they have the *R* gene. Therefore, cucumber breeders have developed white-spined cultivars since the 1940s to keep the fruits green longer (Wehner and Robinson, 1991).

Keeping ability in pickling cucumbers is critical and is related to the method of processing—brining (fermentation), fresh-pack (pasteurization), or cold-pack (refrigeration). Pickling cucumbers often are shipped from remote locations for fresh-pack operations; the time from harvest to processing usually lasts up to a week (Miller and Wehner, 1989). Fresh-pack processing of cucumbers has been widely accepted because of the high quality of the final product (attractive color and improved crispness). Refrigerated products are gaining in consumer popularity. Although they have a limited shelf life, they offer high quality. The perishable nature of cucumbers prevents the economical storage of fresh fruits for longer than 1 month. The advantages of brining over the other two pickling processes are that large quantities of fruits can be stored until needed for processing, and the finished product has a longer shelf life (Lower and Edwards, 1986).

The shelf life and pickling quality of cucumbers can be enhanced by spraying the plants with 100 mg·L⁻¹ K and 5000 mg·L⁻¹ Ca. Further improvement can result when fruits are packaged in perforated polyethylene bags and stored under refrigerated conditions (5 °C and 85% ± 5% RH). This reduces weight loss and fruit decay (Bakr and Gawish, 1993). Fruits treated with thiabendazole [2-(4-thiazolyl) benzimidazole] (a postharvest fungicide) and held in perforated polyethylene bags at room temperature for 9 d lost less weight, had less decay, and were firmer than nontreated controls (Shanan et al., 1978). Keep-

ing quality of greenhouse-grown cucumbers was negatively influenced by certain energy-saving measures (i.e., thermal screens and glasshouses with double roofing) (Janse and Welles, 1984). The removal of field heat immediately after harvest can enhance the postharvest fruit quality of produce (Kays, 1991), and hydrocooling of cucumbers has been recommended to enhance keeping ability. Navazio and Staub (1994) and Thomas and Staub (1992) reported that the most effective treatment was hydrocooling immediately after harvest followed by optimum storage conditions (15 °C and 85% RH).

Optimum storage conditions rarely can be attained in the first few days after harvest. Improved keeping ability of cultivars held at ambient summer temperatures (25–40 °C in North Carolina) would help reduce postharvest losses of fresh-market and pickling cucumbers, and would improve the yield of greenstock purchased and shipped to consumers and processors.

The objective of this study was to evaluate the U.S. Dept. of Agriculture (USDA) cucumber germplasm collection, along with additional cultivars, for keeping ability using rapid methods of measurement. The "best" and "worst" cultigens (cultivars, breeding lines, and plant introduction accessions) identified in the germplasm collection screening study were further retested using more elaborate methods.

Materials and Methods

All experiments were performed at the Horticultural Crops Research Station at Clinton, N.C., using recommended horticultural practices (Hughes et al., 1983; Schultheis, 1990), and optimized field plot trials. Three replications of once-over harvest have been recommended for maximum efficiency to determine which cucumber lines have commercial potential for multiple-harvest trials (Wehner, 1986; Wehner and Miller, 1984). A plot size of 1.2 × 1.5 m was optimum for yield evaluation for once-over harvest of pickling cucumbers (Swallow and Wehner, 1986). Wehner and Miller (1987) recommended the use of small single-row plots without end borders rather than large, multiple-row, bordered plots. Small-plot, single-harvest trials were more efficient than large-plot, multiple-harvest trials, which require more time and labor (Wehner, 1986, 1989; Wehner and Miller, 1984). Swallow and Wehner (1989) reported that maximum information (1/variance) was obtained by allocating test plots of cucumber lines to different seasons and years instead of using different locations and replications. Field plots at Clinton were the best for yield evaluation in North Carolina (Wehner, 1987).

Germplasm tested

Germplasm screening study. A total of 756 cultigens from a total of 44 countries were evaluated in the experiment, including 15 checks. Most of the cultigens were plant introduction accessions; also included were 47

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breeding lines (old cultivars, current cultivars, or experimental inbreds and hybrids). Cultigens designated with a PI number were obtained from the USDA germplasm collection at Ames, Iowa. Old cultivars were obtained from the National Seed Storage Laboratory (NSSL) in Fort Collins, Colo. Countries with the largest number of entries were Turkey, People's Republic of China, Iran, Yugoslavia, India, Japan, and Czechoslovakia. To make them gynoecious, all cultigens were crossed with Gy 14, a gynoecious pickling cucumber inbred, under controlled greenhouse conditions at the Horticultural Science Greenhouses at North Carolina State Univ., Raleigh; this assured fruit set under local field conditions. The cultigens designated "checks" were the cultigens per se (not

the F_1 resulting from a cross with Gy 14). Cultigens with high combining ability for keeping quality should be good genetic sources for direct use in a breeding program. However, cultigens that performed poorly for combining ability might still be good sources for direct use if their superior keeping ability was due primarily to recessive genes. Recessive genes for keeping ability might not be expressed in the hybrid if Gy 14 had dominant genes at the loci involved. Gy 14 was intermediate (212 of 756) in performance for keeping ability, as indicated by loss in fruit weight. Some of the best and worst cultigens were retested as hybrids with Gy 14 and as the cultigen per se, so we were able to measure in part the importance of recessive genes in keeping ability.

Retest study. A total of 20 cultigens were tested for this study. Cultigens in the top 10% for fruit weight loss from the germplasm screening study (Gy 14 x PI220171, Gy 14 x PI279469, Gy 14 x PI321006, Gy x PI211962, Gy 14 x Producer, Gy 14 x PI422177, Regal, PI 220171, Producer, and PI 422177) were chosen to represent cultigens for good keeping ability. Four cultigens in the worst 10% range for fruit loss in the screening study (Wautoma, Gy 14 x PI339244, Gy 14 x PI255934, and PI 339244) were chosen to represent cultigens with the worst keeping ability. Six standard commercial checks were added to the study ('Sumter', 'Wisconsin SMR 18', 'Calypso', 'Poinsett 76', 'Marketmore 76', and 'Dasher II').

Table 1. Keeping ability of fruits of 756 cultigens tested at Clinton, N.C.^z

Cultigen	Seed source ^y	Wt loss (%)	Firm.	
			loss (%)	Shriving ^x
PI 172839	Turkey	-52 ^w	21	6.7
PI 344067	Turkey	-24 ^w	19	7.3
PI 264667	Germany	-11 ^w	11	6.3
PI 171612	Turkey	-2 ^w	6	7.0
PI 339245	Turkey	3	24	6.0
PI 220171	Afghanistan	8	14	4.3
PI 279469	Japan	9	16	5.7
PI 368550	Yugoslavia	9	24	7.7
PI 263047	USSR	10	14	6.3
PI 326597	Hungary	10	13	6.7
PI 343452	USSR	10	16	7.0
Check-Gy 5	Check	10	14	5.0
PI 264230	France	10	6	6.0
PI 344439	Iran	11	14	5.7
PI 277741	Netherlands	11	11	5.7
PI 167197	Turkey	11	14	6.0
PI 182192	Turkey	11	-3 ^w	5.0
PI 263083	P.R. China	11	1	6.0
PI 419079	P.R. China	11	10	5.3
PI 175696	Turkey	12	13	7.0
Ansansky	NSSL	12	22	6.0
PI 357851	Yugoslavia	12	13	6.3
PI 392292	USSR	12	16	5.7
PI 137836	Iran	12	14	6.3
PI 432894	P.R. China	12	16	5.0
PI 321006	Taiwan	12	10	4.7
PI 432895	P.R. China	12	13	5.0
PI 164950	Turkey	12	9	6.0
PI 211962	Iran	12	25	4.3
Producer	NSSL	12	23	6.7
PI 172848	Turkey	12	16	6.0
PI 288993	Hungary	12	12	5.7
PI 376063	Israel	12	7	5.7
PI 204568	Turkey	12	11	5.3
PI 288995	Hungary	12	12	5.3
PI 343451	USSR	12	-1 ^w	6.3
PI 357862	Yugoslavia	12	15	7.0
PI 351139	USSR	12	7	6.7
PI 137839	Iran	12	6	5.7
PI 257487	P.R. China	12	20	6.0
PI 326594	Hungary	12	12	5.7
PI 264666	Germany	12	17	6.3
PI 422177	Czechoslovakia	12	-6 ^w	4.5
Check-Regal	Check	13	-6 ^w	4.3
PI 175691	Turkey	13	17	6.0
PI 288994	Hungary	13	21	5.7
PI 288996	Hungary	13	6	5.3
PI 344349	Turkey	13	11	7.0
PI 209065	U.S.-Ohio	13	14	6.0
PI 222243	Iran	13	8	6.3
PI 209068	U.S.-Ohio	13	9	6.3
PI 267747	U.S.-Oklahoma	13	12	6.7
PI 172849	Turkey	13	18	5.7

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm.	
			loss (%)	Shriving ^x
PI 422191	Czechoslovakia	13	-1 ^w	5.3
PI 137856	Iran	13	4	5.7
PI 355053	Iran	13	0	5.3
PI 171606	Turkey	13	12	6.0
PR 27	NSSL	13	14	5.3
PI 264665	Germany	13	11	6.0
PI 422198	Czechoslovakia	13	14	6.5
PI 169387	Turkey	13	18	6.0
PI 324239	Sweden	13	11	5.7
PI 279464	Japan	13	27	5.0
PI 390954	USSR	13	4	6.3
PI 205995	Sweden	13	18	7.3
Check-Gy 4	Check	13	18	4.7
PI 234517	U.S.-S.C.	13	5	4.0
PI 314425	USSR	13	6	5.7
PI 197086	India	13	30	7.0
PI 280096	USSR	13	13	6.3
PI 432888	P.R. China	13	28	5.0
Check-Gy 2	Check	13	8	5.0
PI 321009	Taiwan	13	15	5.3
PI 292012	Israel	13	13	6.0
PI 279465	Japan	13	11	5.7
PI 211982	Iran	13	15	6.3
PI 267197	P.R. China	14	2	5.0
PI 172851	Turkey	14	18	5.7
PI 164952	Turkey	14	9	6.3
PI 211985	Iran	14	7	5.3
PI 209067	U.S.-Ohio	14	15	5.0
PI 281448	Korea	14	8	5.0
WS Davis Perf.	NSSL	14	5	5.0
PI 368554	Yugoslavia	14	---	6.0
PI 419214	Hong Kong	14	15	4.7
PI 109481	Turkey	14	20	5.3
PI 248778	Iran	14	13	5.7
PI 212233	Japan	14	12	4.7
Shamrock R	NSSL	14	20	5.3
PI 432870	P.R. China	14	22	3.0
PI 176951	Turkey	14	19	5.3
PI 368551	Yugoslavia	14	5	6.0
PI 176952	Turkey	14	10	7.0
PI 183224	Egypt	14	14	5.7
PI 357836	Yugoslavia	14	7	5.7
PI 263084	P.R. China	14	2	5.0
PI 302443	P.R. China	14	9	5.7
PI 357852	Yugoslavia	14	14	4.0
Check-Sprint 440	Check	14	4	3.0
Cubit	NSSL	14	10	4.0
PI 308916	USSR	14	10	6.3
PI 196289	India	14	15	7.0
PI 285603	Poland	14	-5 ^w	4.7
PI 267088	USSR	14	12	7.0
PI 257494	Iran	14	23	6.7
PI 193497	Ethiopia	14	27	7.0

Cultural practices

Germplasm screening study. Seeds were planted on raised, shaped beds 1.5 m apart. Plots were 1.2 m long and 1.5 m wide with 1.2-m alleys at each end. Fourteen seeds were planted in each plot on 12 May and the plants were thinned to a uniform stand of 10 plants per plot on 29 May 1987. No significant disease problems were observed. The guard rows were planted around the field, and at the end of each row. 'Sumter', a monoecious inbred, was planted in border rows and at the ends of each row (62 m long) to provide competition and pollen. Fertilizer was incorporated before planting at a rate of 90N–39P–74K kg·ha⁻¹, with an additional 34

kg·ha⁻¹ N applied at vine tip-over stage. A tank mix of 2.2 kg·ha⁻¹ of naptalam {2-[(1-naphthalenylamino) carbonyl] benzoic acid} and 4.4 kg·ha⁻¹ of bensulide {*O,O*-bis (1-methylethyl) *S*-[2-[(phenylsulfonyl) amino] ethyl] phosphorodithioate} was applied preplant for weed control. Irrigation was applied when needed for a total of 25–40 mm per week. Four fruits were harvested from each plot and evaluated for keeping ability following storage in brown paper bags at room temperature (23 ± 2 °C) and 55% ± 7% RH.

Retest study. Twenty cultigens identified during the initial screening study were planted in the spring season (Table 2). The plots (2.8 × 1.5 m) were separated by 0.3-m

alleys at each end, and had 20 plants each. 'Sumter' was planted at each side of the field, and at each end of the row, to provide competition and pollen. Two harvest dates (1 and 13 July 1988) and two storage environments (an air-conditioned laboratory at 22 ± 2 °C and 55% ± 7% RH and a storage building at 25 ± 3 °C and 79% ± 11% RH without air conditioning) were used in the study. Fruit having a diameter of 40–50 mm were harvested from each plot and three were placed in each of five brown paper bags. Four of the bags were placed in either the laboratory or the storage building for 7 or 14 d. Fruit in the fifth bag were measured immediately upon harvest and were designated the day 0 control.

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm.	
			loss (%)	Shriving ^x
PI 177361	Turkey	14	17	5.5
PI 169389	Turkey	14	0	7.0
PI 257486	P.R. China	14	-5 ^w	6.3
PI 338236	Turkey	14	20	5.0
PI 422181	Czechoslovakia	14	6	4.3
PI 222783	Iran	14	27	6.7
PI 113334	P.R. China	14	22	6.3
PI 092806	P.R. China	14	4	6.0
PI 218036	Iran	14	15	5.3
PI 226510	Iran	14	6	5.7
PI 176526	Turkey	14	6	6.0
PI 188749	Egypt	14	18	6.0
PI 432889	P.R. China	14	15	6.3
PI 326595	Hungary	14	16	6.0
PI 358814	Malaysia	14	24	6.7
PI 267086	USSR	14	26	7.0
PI 344435	Iran	14	13	6.0
PI 169398	Turkey	14	16	6.5
PI 451975	Canada	15	19	5.7
PI 114339	Japan	15	12	5.0
PI 169386	Turkey	15	18	6.3
York State Pickle	NSSL	15	11	5.7
PI 432860	P.R. China	15	13	5.0
PI 370448	Yugoslavia	15	11	6.7
PI 183231	Egypt	15	21	5.3
PI 206954	Turkey	15	24	6.0
PI 285609	Poland	15	19	6.3
PI 283900	Czechoslovakia	15	11	6.7
PI 172845	Turkey	15	13	6.0
PI 419183	P.R. China	15	18	5.0
PI 137857	Iran	15	11	5.3
PI 422176	Czechoslovakia	15	2	5.0
PI 249561	Thailand	15	3	6.3
PI 183677	Turkey	15	23	6.0
PI 211589	Afghanistan	15	16	7.0
PI 419010	P.R. China	15	23	4.0
PI 172847	Turkey	15	13	6.0
PI 344437	Iran	15	19	5.3
PI 175679	Turkey	15	15	6.7
PI 174177	Turkey	15	22	5.7
Calypso	N.C. State Univ.	15	-4 ^w	4.7
PI 175695	Turkey	15	11	6.3
PI 200818	Burma	15	15	5.7
Tiny Dill	NSSL	15	11	6.0
PI 167358	Turkey	15	8	5.7
PI 487424	P.R. China	15	14	5.0
Check-Dasher II	Check	15	10	2.3
PI 288332	India	15	0	5.3
PI 339241	Turkey	15	-12 ^w	6.3
PI 285606	Poland	15	14	5.7
PI 368558	Yugoslavia	15	20	6.3
PI 344347	Turkey	15	4	6.7
PI 178887	Turkey	15	18	6.3

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm.	
			loss (%)	Shriving ^x
PI 357850	Yugoslavia	15	11	6.3
PI 211728	Afghanistan	15	7	5.7
PI 229309	Iran	15	44	7.0
PI 209064	U.S.-Ohio	15	7	6.0
PI 356809	USSR	15	16	6.7
Check-Calypso	Check	15	14	4.0
PI 174170	Turkey	15	4	6.0
Snows Pickling	NSSL	15	18	4.3
PI 275411	Netherlands	15	9	6.3
PI 222099	Afghanistan	15	13	6.7
National Pickling	NSSL	15	12	5.3
PI 169304	Turkey	15	21	6.7
PI 288237	Egypt	15	3	5.7
PI 227209	Japan	15	18	7.0
PI 227664	Iran	15	20	6.0
PI 283902	Czechoslovakia	15	25	6.3
Check-M 21	Check	15	13	4.0
PI 174173	Turkey	15	14	5.3
PI 321008	Taiwan	15	25	6.3
PI 172852	Turkey	15	13	6.3
PI 314426	USSR	15	15	6.0
PI 339247	Turkey	15	13	6.7
PI 264226	France	15	17	6.0
PI 279463	Japan	15	18	5.7
PI 344348	Turkey	15	12	6.7
PI 436609	P.R. China	15	6	6.0
PI 369717	Poland	15	27	6.5
PI 418964	P.R. China	15	15	4.0
PI 177360	Turkey	15	13	6.0
PI 390257	Japan	15	14	4.3
PI 419078	P.R. China	15	17	3.3
PI 172844	Turkey	15	5	6.0
PI 169315	Turkey	15	16	7.0
PI 414158	U.S.-Hawaii	15	9	3.7
PI 169397	Turkey	16	6	6.7
PI 211980	Iran	16	5	6.3
PI 288238	Egypt	16	26	5.7
M 21	N.C. State Univ.	16	5	4.3
PI 264668	Germany	16	5	6.0
PI 179921	India	16	13	7.0
PI 466922	USSR	16	7	4.7
PI 458853	USSR	16	0	6.5
PI 220790	Afghanistan	16	27	7.0
PI 105340	P.R. China	16	9	6.0
PI 211975	Iran	16	19	6.3
PI 419017	P.R. China	16	15	3.7
PI 321011	Taiwan	16	4	3.5
PI 344353	Turkey	16	7	7.7
PI 227208	Japan	16	23	3.7
PI 165499	India	16	3	7.0
PI 432893	P.R. China	16	19	6.0
PI 211978	Iran	16	15	4.7
Gy 14	N.C. State Univ.	16	29	4.5

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shrivelings ^x
PI 211117	Israel	16	23	4.7
PI 172838	Turkey	16	16	6.3
PI 175120	India	16	20	7.0
PI 172846	Turkey	16	3	6.3
PI 432883	P.R. China	16	7	4.7
PI 338234	Turkey	16	20	7.0
PI 458852	USSR	16	12	5.0
PI 478367	P.R. China	16	12	5.3
PI 233932	Canada	16	14	7.3
PI 135123	New Zealand	16	-2 ^w	7.3
PI 251519	Iran	16	26	7.0
PI 109483	Turkey	16	-6 ^w	4.7
Texas Long	NSSL	16	18	3.0
Clinton	N.C. State Univ.	16	6	5.0
PI 211979	Iran	16	14	5.7
Model	NSSL	16	9	5.3
PI 344351	Turkey	16	18	6.3
PI 176517	Turkey	16	4	6.3
Early Green Cluster	NSSL	16	7	7.0
PI 357844	Yugoslavia	16	13	7.0
PI 432866	P.R. China	16	2	5.3
PI 103049	P.R. China	16	19	5.3
PI 344444	Iran	16	17	4.0
PI 211977	Iran	16	-4 ^w	6.7
PI 174172	Turkey	16	6	5.7
PI 206425	Turkey	16	4	6.3
PI 171611	Turkey	16	25	7.0
PI 222985	Iran	16	15	5.7
PI 169402	Turkey	16	13	5.7
PI 257286	Spain	16	16	5.7
PI 344445	Iran	16	25	5.3
PI 344441	Iran	16	26	5.3
PI 175693	Turkey	16	18	6.0
PI 357859	Yugoslavia	16	14	7.0
PI 432850	P.R. China	16	21	6.3
PI 264664	Germany	16	13	5.7
PI 271753	Netherlands	16	14	5.0
PI 432892	P.R. China	16	21	5.7
PI 390255	Japan	16	20	3.0
PI 171605	Turkey	16	5	7.0
PI 269480	West Pakistan	16	17	6.3
PI 342950	Denmark	16	15	6.7
Early Fortune	NSSL	16	5	6.3
PI 432867	P.R. China	16	25	5.7
PI 169392	Turkey	16	23	6.0
PI 326598	Hungary	16	2	5.7
PI 292011	Israel	16	28	5.7
Sprint 440	Asgrow	17	17	4.7
PI 172843	Turkey	17	29	7.3
PI 137853	Iran	17	12	5.7
PI 264229	France	17	22	4.0
Delcrow	NSSL	17	14	4.5
PI 401733	Puerto Rico	17	10	4.0
PI 179676	India	17	21	4.3
PI 436610	P.R. China	17	20	4.3
PI 379282	Yugoslavia	17	11	8.0
PI 427090	P.R. China	17	25	5.0
PI 137848	Iran	17	20	6.7
PI 357845	Yugoslavia	17	10	6.3
PI 432879	P.R. China	17	19	6.0
PI 435946	USSR	17	16	5.7
PI 167134	Turkey	17	5	6.0
PI 478365	P.R. China	17	17	4.7
PI 432865	P.R. China	17	8	4.3
PI 354952	Denmark	17	12	6.0
PI 357841	Yugoslavia	17	8	6.3
PI 175686	Turkey	17	26	6.7
PI 263082	P.R. China	17	20	5.7
PI 401734	Puerto Rico	17	11	4.3
PI 109484	Turkey	17	2	6.0
PI 418963	P.R. China	17	11	4.3
PI 204692	Turkey	17	19	4.7
PI 167079	Turkey	17	18	5.0
PI 285604	Poland	17	14	4.7
PI 293432	Lebanon	17	19	6.3

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shrivelings ^x
PI 288992	Hungary	17	16	5.3
PI 285605	Poland	17	37	6.7
PI 171604	Turkey	17	9	6.7
PI 419108	P.R. China	17	23	5.0
PI 283899	Czechoslovakia	17	15	5.7
PI 226461	Iran	17	17	6.3
PI 169353	Turkey	17	18	6.0
PI 357865	Yugoslavia	17	7	6.0
PI 422186	Czechoslovakia	17	11	5.0
PI 432853	P.R. China	17	14	4.3
PI 182190	Turkey	17	14	6.0
PI 169383	Turkey	17	17	7.0
PI 390246	Japan	17	18	4.0
PI 246930	Afghanistan	17	11	5.3
PI 167050	Turkey	17	8	4.5
PI 489754	P.R. China	17	27	4.0
PI 390951	USSR	17	60	7.5
PI 357860	Yugoslavia	17	11	6.3
PI 172841	Turkey	17	5	5.7
Boston Pickling	NSSL	17	17	6.7
PI 222987	Iran	17	10	6.3
PI 263080	USSR	17	13	6.7
PI 326596	Hungary	17	19	5.3
PI 357837	Yugoslavia	17	9	6.7
Arlington WS	NSSL	17	21	5.0
PI 181756	Lebanon	17	6	5.7
PI 171600	Turkey	17	14	7.0
PI 379278	Yugoslavia	17	5	6.3
PI 169381	Turkey	17	19	6.3
PI 422168	Czechoslovakia	17	14	4.7
PI 458849	USSR	17	16	6.3
PI 204690	Turkey	17	11	5.7
PI 357839	Yugoslavia	18	11	5.3
PI 422185	Czechoslovakia	18	9	5.3
PR 39	NSSL	18	16	4.7
PI 321007	Taiwan	18	23	5.7
PI 192940	P.R. China	18	19	6.3
PI 226509	Iran	18	21	6.7
PI 390247	Japan	18	31	3.3
PI 344432	Iran	18	13	6.3
PI 355055	Iran	18	4	6.7
PI 356833	GBE	18	26	4.3
PI 175690	Turkey	18	9	5.7
PI 176957	Turkey	18	6	6.0
PI 177363	Syria	18	14	5.7
PI 275412	Netherlands	18	21	5.3
PI 167052	Turkey	18	14	6.7
Favor II	NSSL	18	11	6.7
PI 432859	P.R. China	18	12	4.7
PI 169391	Turkey	18	7	6.3
PI 296387	Iran	18	15	7.0
PI 261608	Spain	18	8	5.0
PI 169401	Turkey	18	0	6.7
PI 368549	Yugoslavia	18	18	7.0
PI 181910	Syria	18	20	5.3
PI 267743	P.R. China	18	12	5.0
PI 227210	Japan	18	26	5.3
PI 182188	Turkey	18	20	5.7
PI 357831	Yugoslavia	18	21	7.0
PI 357868	Yugoslavia	18	17	5.7
PI 344352	Turkey	18	1	6.7
PI 212599	Afghanistan	18	13	7.0
PI 174167	Turkey	18	20	5.0
PI 181940	Syria	18	23	4.7
PI 390256	Japan	18	14	6.0
PI 197087	India	18	18	6.7
PI 178884	Turkey	18	31	7.3
PI 222782	Iran	18	25	6.0
PI 249550	Iran	18	15	5.7
PI 137835	Iran	18	21	6.0
PI 218199	Lebanon	18	25	7.0
PI 344438	Iran	18	15	6.0
PI 179260	Turkey	18	21	6.0
PI 172840	Turkey	18	18	5.0
PI 172842	Turkey	18	24	6.3

Traits measured

Germplasm screening study. Data were collected on: fruit weight loss (%), firmness loss (%), and a visual rating for appearance (fruit shriveling). Fruit weight was measured before storage and after 2 weeks, when the fruits were rated for shriveling and firmness. Shriveling was rated subjectively on a 0–9 scale with 0 = none (no appearance of shriveling of fruit skin), 1–3 = slight, 4–6 = moderate, and 7–9 = severe (skin very shriveled). Firmness was the amount of force (N) required to penetrate the exocarp (skin) and mesocarp (flesh) with an 8-mm-diameter tester head (McCormick Fruit Tech, Yakima, Wash.) on the top carpel of the blossom end of the fruit.

Retest study. Data were recorded 0, 7, and 14 d after harvest. The traits measured were fresh weight, firmness, percentage of shriveling, degree of yellowing, incidence of postharvest diseases, fresh taste, seedcell wateriness, placental hollows, and carpel separation.

Quality traits (taste, seedcell, placental hollows, and carpel separation) were rated subjectively on a 1–9 scale (1–3 = poor, 4–6 = intermediate, 7–9 = excellent). Taste ratings of 1–3 indicated a bad flavor or bitter taste, 4–6 a slightly off-flavor, and 7–9 a good flavor and sweet taste. Seedcell wateriness was rated based on the degree to which the firm, crisp seedcell became soft and watery; ratings of 1–3 indicated that the seedcell was very watery, and a rating of 7–9 indicated that it was firm

and crisp. Placental hollows rating was based on the length of placental hollows in the fruit. A rating of 1–3 indicated two or three hollows running most of the length of the fruits, 4–6 indicated one or two placental hollows running less than the entire length of the fruit, and 7–9 indicated that there was no defect (or no more than one placental hollow running less than half the length of the fruit). Carpel separation was rated based on the degree of carpel separation. A rating of 1–3 indicated carpels separated, and the center of the fruit hollow, 4–6 indicated carpels obviously separated, and 7–9 indicated that there was no defect (or carpels slightly but not obviously separated). Average quality, damage index, percentage loss in fresh fruit weight, and percentage of

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriveling ^x
PI 176956	Turkey	18	12	5.7
Straight 8	NSSL	18	23	4.3
PI 109482	Turkey	18	13	7.0
PI 306785	Canada	18	22	3.7
PI 274902	Great Britain	18	10	5.7
PI 249562	Thailand	18	15	4.0
PI 163217	India	18	5	6.3
PI 357867	Yugoslavia	18	9	6.0
Everbearing	NSSL	18	2	5.7
PI 227207	Japan	18	22	5.0
PI 135122	New Zealand	18	40	7.0
PI 174164	Turkey	18	30	6.7
PI 478364	P.R. China	18	9	5.0
PI 414159	U.S.–Hawaii	18	–8 ^w	4.7
PI 458848	USSR	18	6	7.0
PI 262990	Netherlands	18	16	6.7
PI 137846	Iran	18	8	6.0
PI 379285	Yugoslavia	18	8	5.3
PI 390265	Japan	18	38	7.0
PI 251520	Iran	18	18	7.3
PI 178886	Turkey	18	19	6.0
PI 379287	Yugoslavia	18	2	6.7
PI 271331	India	19	19	7.0
PI 169403	Turkey	19	17	5.7
PI 271754	Netherlands	19	15	6.0
PI 432857	P.R. China	19	47	5.7
PI 379284	Yugoslavia	19	–13 ^w	5.0
PI 400270	Japan	19	24	7.0
PI 223437	Afghanistan	19	7	6.3
PI 165506	India	19	22	7.0
PI 458855	USSR	19	6	6.5
PI 206952	Turkey	19	18	6.0
PI 169388	Turkey	19	22	6.3
PI 489752	P.R. China	19	20	5.7
PI 422172	Czechoslovakia	19	18	4.7
PI 390953	USSR	19	10	7.0
PI 175683	Turkey	19	6	6.3
PI 171601	Turkey	19	22	5.7
PI 308915	USSR	19	18	6.7
PI 355052	Israel	19	8	6.0
PI 368548	Yugoslavia	19	16	6.7
PI 357857	Yugoslavia	19	23	7.0
PI 339246	Turkey	19	19	7.0
PI 179259	Turkey	19	6	6.0
PI 267087	USSR	19	6	6.3
PI 176516	Turkey	19	16	6.0
PI 482464	Zimbabwe	19	22	4.0
PI 255936	Netherlands	19	34	6.7
PI 165029	Turkey	19	19	6.7
PI 175680	Turkey	19	9	7.0
PI 171602	Turkey	19	22	6.3
PI 267942	Japan	19	11	6.7

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriveling ^x
PI 267746	India	19	7	7.0
PI 183445	India	19	23	6.7
PI 220789	Afghanistan	19	16	5.7
Shogoin	NSSL	19	27	5.7
PI 304803	U.S.–New York	19	21	5.3
PI 357854	Yugoslavia	19	9	6.5
PI 169380	Turkey	19	14	6.3
PI 181753	Syria	19	14	5.7
PI 175694	Turkey	19	27	6.3
PI 106063	P.R. China	19	7	6.3
PI 391569	P.R. China	20	11	5.5
PI 344350	Turkey	20	27	6.7
PI 356832	Netherlands	20	3	5.3
PI 285607	Poland	20	3	6.7
PI 344433	Iran	20	13	5.7
PI 179678	India	20	12	4.7
PI 339250	Turkey	20	25	6.7
PI 177359	Turkey	20	23	4.7
PI 173889	India	20	20	5.7
PI 436673	P.R. China	20	31	4.7
Check–WI 2757	Check	20	---	4.0
PI 390952	USSR	20	11	5.3
PI 164734	India	20	1	6.7
PI 401732	Puerto Rico	20	26	5.7
PI 422180	Czechoslovakia	20	31	4.5
PI 489753	P.R. China	20	18	5.7
PI 211988	Iran	20	8	5.7
PI 209069	U.S.–Ohio	20	24	6.3
PI 271334	India	20	18	6.7
PI 436648	P.R. China	20	26	5.0
PI 422196	Czechoslovakia	20	30	4.0
PI 458847	USSR	20	14	5.7
PI 269482	West Pakistan	20	14	6.3
PI 292010	Israel	20	8	5.0
PI 165046	Turkey	20	24	6.5
PI 135345	Afghanistan	20	21	6.3
PI 217644	India	20	29	7.3
PI 321010	Taiwan	20	13	6.7
PI 262974	India	20	24	6.3
PI 435947	USSR	20	19	6.3
PI 267935	Japan	20	16	7.0
PI 458850	USSR	20	6	7.0
PI 169394	Turkey	20	19	5.7
PI 390259	Japan	20	7	6.3
PI 171610	Turkey	20	19	7.0
PI 418989	P.R. China	20	8	7.5
PI 169351	Turkey	20	27	7.7
PI 390252	Japan	20	18	6.7
PI 175111	India	20	1	6.0
PI 263081	P.R. China	21	26	6.7
PI 211967	Iran	21	9	6.7
PI 319216	Un. Arab Repub.	21	11	6.3

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shrivelings ^x
PI 338235	Turkey	21	8	6.0
PI 179263	Turkey	21	31	7.0
PI 169396	Turkey	21	17	6.7
PI 164819	India	21	20	7.7
PI 169393	Turkey	21	12	6.7
PI 212059	Greece	21	15	5.3
PI 390258	Japan	21	46	6.7
PI 357849	Yugoslavia	21	14	7.0
PI 422190	Czechoslovakia	21	21	4.3
PI 250147	W. Pakistan	21	8	6.7
PI 263049	USSR	21	17	6.3
PI 357835	Yugoslavia	21	3	6.5
PI 163214	India	21	23	7.3
PI 263079	USSR	21	26	4.7
PI 174166	Turkey	21	33	7.0
PI 169400	Turkey	21	11	6.7
PI 176954	Turkey	21	34	7.0
PI 164670	India	21	11	5.0
PI 206043	U.S.-Puerto Rico	21	37	6.7
PI 418962	P.R. China	21	27	5.0
PI 137847	Iran	21	45	7.7
PI 422170	Czechoslovakia	21	28	5.3
PI 178888	Turkey	21	29	7.3
PI 419136	P.R. China	21	16	5.3
PI 432890	P.R. China	21	19	5.3
PI 357840	Yugoslavia	21	31	7.0
PI 209066	U.S.-Ohio	21	29	7.0
PI 263048	USSR	21	16	7.0
PI 176953	Turkey	21	45	7.0
PI 267943	Japan	21	23	7.3
PI 419009	P.R. China	21	11	4.7
Muronium	NSSL	21	57	7.0
PI 171609	Turkey	21	36	6.7
PI 390262	Japan	21	34	4.5
PI 357847	Yugoslavia	21	25	5.0
Polaris	NSSL	21	41	5.5
PI 306180	Poland	21	17	6.0
Check-Addis	Check	21	-6 ^w	6.0
PI 483342	Korea	21	24	5.0
PI 221440	Afghanistan	22	12	6.0
PI 390269	Japan	22	15	7.0
PI 370449	Yugoslavia	22	18	8.0
PI 344434	Iran	22	17	6.0
White Wonder	NSSL	22	3	6.3
PI 422188	Czechoslovakia	22	31	6.0
Pacer	Harris-Moran	22	---	3.0
PI 181874	Syria	22	20	6.0
PI 206953	Turkey	22	18	7.0
Long of Keschmet	NSSL	22	27	7.0
PI 344440	Iran	22	12	5.7
PI 432873	P.R. China	22	38	6.3
PI 390253	Japan	22	20	7.0
PI 137844	Iran	22	18	7.5
PI 422173	Czechoslovakia	22	10	6.0
PI 167389	Turkey	22	36	7.0
PI 391568	P.R. China	22	26	6.7
PI 173892	India	22	28	6.0
PI 344443	Iran	22	15	6.7
PI 357863	Yugoslavia	22	16	6.0
PI 169385	Turkey	22	27	7.7
PI 207476	Afghanistan	22	19	5.3
PI 304805	U.S.-New York	22	17	6.5
PSI	NSSL	22	20	4.3
PI 174174	Turkey	22	18	6.3
PI 173674	Turkey	22	35	7.3
PI 391573	P.R. China	22	33	5.0
PI 368556	Yugoslavia	22	36	7.7
PI 289698	Australia	22	5	6.3
PI 211984	Iran	22	12	5.0
PI 211943	Iran	22	14	6.3
PI 109275	Turkey	22	18	6.7
PI 414157	U.S.-Oregon	22	20	6.7
PI 360939	Netherlands	22	15	6.7
PI 279468	Japan	23	24	7.0
PI 193496	Ethiopia	23	13	6.7

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shrivelings ^x
PI 164816	India	23	2	7.7
PI 181942	Syria	23	24	5.3
PI 296121	Egypt	23	12	7.0
PI 293923	U.S.-S.C.	23	35	7.0
Check-Sumter	Check	23	20	6.7
PI 264231	France	23	22	7.3
PI 390266	Japan	23	24	6.5
PI 182189	Turkey	23	13	5.7
PI 163213	India	23	22	6.0
PI 390248	Japan	23	31	7.5
PI 176924	Turkey	23	32	7.7
PI 357834	Yugoslavia	23	29	7.0
PI 390240	Japan	23	34	8.0
PI 181752	Syria	23	39	7.0
PI 211983	Iran	23	27	6.0
PI 370450	Yugoslavia	23	58	7.5
PI 255933	Netherlands	23	23	5.3
PI 339248	Turkey	23	21	5.3
PI 357830	Yugoslavia	23	53	7.0
PI 432877	P.R. China	23	19	6.5
PI 373918	England	23	21	6.3
PI 275410	Netherlands	23	13	6.3
PI 372898	Netherlands	23	26	5.3
PI 255937	Netherlands	24	23	6.0
PI 357843	Yugoslavia	24	26	8.0
Chicago Pickling	NSSL	24	15	7.0
PI 357848	Yugoslavia	24	18	7.0
PI 204567	Turkey	24	28	6.7
Palmetto	NSSL	24	40	6.3
PI 436672	P.R. China	24	18	6.3
PI 422171	Czechoslovakia	24	35	6.7
PI 481617	Bhutan	24	15	4.0
PI 214049	India	24	18	7.7
PI 222720	Iran	24	42	7.5
PI 390250	Japan	24	35	6.3
PI 432861	P.R. China	24	30	6.7
PI 169378	Turkey	24	22	7.7
PI 164743	India	24	15	6.7
PI 432875	P.R. China	24	34	7.0
PI 357855	Yugoslavia	24	11	7.3
PI 175688	Turkey	24	25	5.0
PI 175689	Turkey	24	19	5.7
PI 164173	India	24	14	6.7
PI 264227	France	25	31	6.3
PI 422174	Czechoslovakia	25	45	7.0
PI 267741	Japan	25	12	6.7
PI 432858	P.R. China	25	15	6.7
PI 174160	Turkey	25	22	7.3
PI 357833	Yugoslavia	25	41	8.7
PI 200815	Burma	25	36	5.7
PI 176521	Turkey	25	27	7.3
PI 169395	Turkey	25	31	8.3
PI 344442	Iran	25	22	6.3
Pixie	NSSL	25	1	4.3
PI 175681	Turkey	25	11	7.5
PI 306179	Poland	25	34	7.7
PI 227013	Iran	25	47	7.3
PI 422169	Czechoslovakia	25	61	7.3
PI 357832	Yugoslavia	25	24	6.7
Wautoma	USDA-Wis	25	31	5.0
PI 217946	Pakistan	25	31	7.0
PI 204569	Turkey	25	44	7.7
PI 432848	P.R. China	26	43	6.7
PI 263078	USSR	26	29	6.7
PI 432855	P.R. China	26	32	8.5
PI 264228	France	26	5	6.7
PI 177364	Iraq	26	30	6.7
PI 183127	India	26	---	9.0
PI 206955	Turkey	26	19	7.3
PI 390241	Japan	26	26	4.0
PI 284699	Sweden	26	35	7.3
Delicatesse	NSSL	26	8	6.7
PI 370447	Yugoslavia	26	6	6.5
PI 267742	P.R. China	26	31	7.3
PI 175950	Turkey	26	9	6.7

loss in firmness were calculated from the data. Average quality was the mean of the ratings for taste, seedcell wateriness, placental hollows, and carpel separation.

Damage traits (shriveling, fruit yellowing, and postharvest diseases) were rated subjectively on a 0–9 scale (0 = none, 1–3 = slight, 4–6 = moderate, 7–9 = severe), and damage index was calculated as the mean of the three values. Percentage of loss in fruit weight and fruit firmness were calculated based on the formulas described for the germplasm screening study.

Data analysis

Germplasm screening study. The experiment was a randomized complete-block design

with 761 cultigens and three replications. Data were analyzed using the GLM and CORR procedures of SAS (SAS Inst., Cary, N.C.).

Retest study. The experiment was performed using a factorial treatment arrangement in a randomized complete-block design with two replications of nine fruits per treatment combination [two harvest dates (1 and 13 July) × two storage locations × 20 cultigens]. Data were analyzed using the GLM and CORR procedures of SAS (SAS Inst.).

Results and Discussion

Germplasm screening study. Differences among cultigens in percentage of fruit weight loss, percentage of fruit firmness loss, and

degree of fruit shriveling during storage were highly significant. Cultigens were ranked based on the mean values for the percentage of fruit weight loss over the three replications (Table 1). Correlation analysis revealed that there were only moderate associations for percentage of fruit weight loss vs. fruit firmness loss ($r = 0.60$), percentage of fruit weight loss vs. shriveling rating ($r = 0.44$), and fruit firmness loss vs. shriveling rating ($r = 0.45$) (Table 1).

Cultigens with the lowest percentage of fruit weight loss (<10%) were PI 172839, PI 344067, PI 264667, PI 171612, PI 339245, PI 220171, PI 279469, and PI 368550 (Table 1), and the cultigen with the highest percentage (70%) was PI 357864. Cultigens with the lowest percentage of loss in fruit firmness

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriveling ^x
PI 171608	Turkey	26	39	7.3
PI 224668	Korea	27	39	6.7
Earliest of All	NSSL	27	19	5.7
Nappa 63	NSSL	27	2	6.5
MR 200	NSSL	27	21	6.0
PI 267745	Brazil	27	28	6.7
PI 169377	Turkey	27	14	7.0
PI 432862	P.R. China	27	26	6.0
PI 478366	P.R. China	27	36	7.0
PI 269481	West Pakistan	27	20	7.7
Robin	NSSL	27	19	6.3
PI 458851	USSR	27	31	7.7
PI 390244	Japan	27	29	8.0
PI 137845	Iran	27	32	6.3
PI 263046	USSR	27	25	6.0
PI 211986	Iran	28	18	7.0
PI 390239	Japan	28	38	7.0
PI 419041	P.R. China	28	29	8.0
PI 176523	Turkey	28	47	7.3
PI 357869	Yugoslavia	28	33	7.3
PI 176525	Turkey	28	13	7.7
PI 212985	India	28	28	8.0
PI 432886	P.R. China	28	36	6.7
Sunny South	NSSL	28	12	5.7
PI 372587	Netherlands	28	26	6.0
PI 261609	Spain	28	26	6.3
PI 163221	India	28	45	6.5
PI 379283	Yugoslavia	28	0	7.0
PI 372893	Netherlands	29	37	7.0
PI 422167	Czechoslovakia	29	21	7.0
PI 432851	P.R. China	29	52	8.0
PI 105263	Turkey	29	25	6.7
Staygreen	NSSL	29	10	5.0
PI 357842	Yugoslavia	29	42	6.0
PI 228344	Iran	29	24	6.3
PI 296120	Egypt	30	31	7.0
PI 255938	Netherlands	30	24	8.0
Check–SMR 58	Check	30	22	7.7
PI 176524	Turkey	30	10	6.0
PI 169319	Turkey	30	5	6.0
PI 137851	Iran	30	12	5.7
PI 220860	Korea	31	17	6.0
PI 458846	USSR	31	33	7.0
PI 422192	Czechoslovakia	31	19	6.7
PI 175692	Turkey	31	42	7.0
PI 271328	India	31	26	7.7
PI 267744	P.R. China	31	37	6.3
PI 164284	India	31	19	7.7
PI 255935	Netherlands	31	20	5.7
PI 379280	Yugoslavia	31	65	8.0
PI 419135	P.R. China	31	47	7.3
PI 169328	Turkey	32	41	8.3

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriveling ^x
PI 390264	Japan	32	40	6.7
PI 357856	Yugoslavia	32	62	8.5
PI 279466	Japan	32	27	7.5
PI 265887	Netherlands	32	56	7.0
PI 169384	Turkey	32	45	7.3
PI 432871	P.R. China	33	65	7.0
PI 220169	Afghanistan	33	27	7.0
PI 390260	Japan	33	42	7.3
PI 212896	India	33	---	5.0
PI 390261	Japan	33	21	7.0
PI 483344	Korea	33	66	8.0
PI 339243	Turkey	33	24	8.3
PI 422200	Czechoslovakia	33	25	7.0
PI 169334	Turkey	33	47	7.7
PI 164951	Turkey	33	41	7.7
PI 227235	Iran	33	21	6.3
PI 173893	India	34	31	8.0
PI 432864	P.R. China	34	48	8.3
PI 368560	Yugoslavia	34	16	6.7
PI 169350	Turkey	34	41	7.7
PI 279467	Japan	34	23	7.7
PI 169352	Turkey	35	44	7.3
PI 169390	Turkey	35	50	6.7
PI 357858	Yugoslavia	35	39	6.7
PI 368552	Yugoslavia	35	30	7.7
PI 368559	Yugoslavia	35	---	8.0
PI 171613	Turkey	35	8	5.3
PI 422182	Czechoslovakia	36	13	4.3
Check–M 27	Check	36	46	7.7
PI 432882	P.R. China	37	---	9.0
PI 205181	Turkey	37	37	8.5
PI 288991	Hungary	38	41	6.7
PI 458856	USSR	38	60	6.3
PI 285608	Poland	38	22	8.0
PI 342951	Denmark	38	39	7.7
PI 202801	Syria	38	34	8.0
PI 165509	India	38	24	8.3
PI 368557	Yugoslavia	38	6	8.0
PI 283901	Czechoslovakia	39	30	6.0
PI 197085	India	39	58	8.0
PI 368555	Yugoslavia	39	47	8.5
PI 390267	Japan	40	44	6.0
PI 223841	Philippines	40	37	7.3
PI 379281	Yugoslavia	40	62	8.0
PI 436608	P.R. China	41	30	5.5
PI 271326	India	41	22	8.0
PI 222244	Iran	41	31	6.3
PI 422179	Czechoslovakia	41	28	6.0
PI 167043	India	42	46	6.7
PI 169382	Turkey	42	62	7.7
PI 176519	Turkey	42	41	6.0
PI 432896	P.R. China	43	67	7.7

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriving ^x
PI 220791	Afghanistan	43	39	7.3
PI 118279	Brazil	43	59	8.0
GiantWtArnsstadt	NSSL	44	58	9.0
PI 171607	Turkey	44	44	7.0
PI 271327	India	44	75	6.7
Davis Perfect	NSSL	46	61	7.0
Stono	NSSL	46	---	9.0
PI 167198	Turkey	46	41	6.0
PI 390251	Japan	46	26	6.0
PI 391570	P.R. China	47	63	8.0
PI 288990	Hungary	47	43	6.3
PI 176522	Turkey	47	47	7.3
PI 222986	Iran	48	65	8.3
Redlands	Australia	48	38	8.3
PI 432863	P.R. China	50	61	8.3
PI 197088	India	50	59	8.0
Magnolia	NSSL	51	58	8.5
Check-Wautoma	Check	51	50	8.5
PI 285610	Poland	52	48	7.3
PI 357838	Yugoslavia	52	48	8.0
PI 163223	India	52	54	8.7
PI 422184	Czechoslovakia	53	7	8.5
PI 339244	Turkey	53	77	8.0
PI 432885	P.R. China	55	11	6.5
PI 255934	Netherlands	56	73	7.7
PI 432874	P.R. China	58	---	9.0
PI 368553	Yugoslavia	60	100	9.0

Table 1. Continued.

Cultigen	Seed source ^y	Wt loss (%)	Firm. loss (%)	Shriving ^x
PI 357864	Yugoslavia	70	---	9.0
LSD (5%)		21	32	1.9
Mean		20	20	6.2
CV (%)		64	101	19
Range		122	113	7
Range/LSD		6	4	4

Correlations r (% weight lost vs. % firmness lost) = 0.60** r (% weight lost vs. shriveling rating) = 0.44** r (% firmness lost vs. shriveling rating) = 0.45** r (keeping rating vs. shriveling rating) = -0.50** r (keeping rating vs. % weight loss) = -0.85** r (keeping rating vs. % firmness loss) = -0.94**

^zData are means for three replications of three fruits each. Cultigens listed were used as the male parent to produce a hybrid with Gy 14 (with the exception of those listed as checks, which were the actual cultigens). Cultigens designated with a PI number came from the USDA germplasm collection in Ames, Iowa. The NSSL seed source is the National Seed Storage Laboratory in Fort Collins, Colo.

^ySome countries listed now no longer exist as political units (Czechoslovakia, USSR, Yugoslavia).

^xRated from 0 to 9 (0 = no shriveling, 1–3 = slight shriveling and discoloring, 4–6 = moderate shriveling and discoloring, 7–9 = severe shriveling and discoloring).

^wNegative values are due to sampling error.

**Significant at $P = 0.01$.

Table 2. Mean keeping ability of 20 cucumber cultigens over two locations after storage for 0 and 14 d.^z

Cultigen	Seed source	Avg quality ^y	Damage index ^x	Wt loss (%)	Firm. loss (%)	Fruit Taste ^a	Seed-cell ^w	Plac. hollow ^w	Carpel sep. rating ^w	Shriveling	Fruit yellow rating	Disease rating ^y
Control (0 d storage)												
Calypso	Petoseed	6.5	1.8	17	12	4.0	4.0	8.8	9.0	2.5	3.5	0.0
Regal	N.C. State Univ.	6.2	1.5	-8	8	3.8	3.3	8.6	9.0	1.9	2.9	0.1
Gy 14 x PI422177	N.C. State Univ.	6.1	1.5	15	10	3.7	3.4	8.6	8.7	2.7	2.3	0.7
Wautoma	USDA-Wis.	6.0	1.6	6	5	3.2	3.0	9.0	9.0	1.8	3.2	0.0
Gy 14 x Producer	N.C. State Univ.	6.0	2.0	16	12	4.2	2.8	8.7	8.5	2.2	4.0	0.0
Gy 14 x PI255934	N.C. State Univ.	6.0	1.6	22	13	2.6	3.5	9.0	9.0	3.6	2.9	0.4
PI 339244	Turkey	6.0	1.5	30	27	3.0	3.0	9.0	9.0	3.5	3.0	0.0
Gy 14 x PI339244	N.C. State Univ.	6.0	3.1	-5	10	3.0	3.3	8.8	8.9	2.9	5.4	0.8
Gy 14 x PI211962	N.C. State Univ.	6.0	2.4	8	11	3.7	3.4	8.1	8.6	2.1	4.1	0.7
Sumter	Asgrow Seed	5.9	2.4	9	15	2.7	2.9	9.0	9.0	3.9	4.1	0.6
Dasher II	Petoseed	5.9	0.6	26	10	3.3	3.0	8.5	8.8	1.1	1.1	0.1
Marketmore 76	Asgrow Seed	5.9	0.9	-5	-1	2.8	2.8	9.0	9.0	1.8	1.8	0.0
Gy 14 x PI279469	N.C. State Univ.	5.9	3.9	33	21	3.2	3.0	8.4	8.8	4.6	6.6	1.2
Poinsett 76	Petoseed	5.8	0.9	-8	9	3.5	3.2	8.3	8.2	1.7	1.8	0.0
Gy 14 x PI321006	N.C. State Univ.	5.8	1.4	-6	6	3.6	3.9	7.6	8.0	2.4	2.7	0.0
PI 220171	Afghanistan	5.8	1.8	---	---	2.5	2.5	9.0	9.0	2.0	3.5	0.0
PI 422177	Czechoslovakia	5.8	2.4	16	4	2.8	2.6	9.0	8.6	3.0	3.8	1.0
Gy 14 x PI220171	N.C. State Univ.	5.7	2.3	10	18	2.8	2.9	8.5	8.5	3.0	4.0	0.6
Wis. SMR 18	Northrup King	5.6	2.9	10	9	3.4	3.3	7.8	8.1	3.1	5.9	0.0
Producer	NSSL	5.1	3.3	2	10	3.0	2.1	7.1	8.0	3.3	5.6	1.0
<i>Statistics</i>												
LSD (5%)		NS	1.0	NS	NS	NS	NS	NS	NS	1.2	1.3	NS
Mean		5.9	2.0	8.6	10.5	3.3	3.1	8.5	8.6	2.6	3.7	0.4
CV (%)		10	59	345	125	30	34	16	11	45	37	345
<i>Means for harvest date (d)</i>												
7 d		7.3	1.5	-4.7	3.0	6.7	5.6	8.5	8.5	1.2	2.8	0.3
14 d		5.9	2.0	8.6	10.5	3.3	3.1	8.5	8.6	2.6	3.7	0.4
<i>Location (14 d only)</i>												
Shed		5.8	2.0	12.3	14.4	3.1	3.1	8.4	8.6	3.0	3.5	0.5
Lab		6.0	2.0	6.7	6.8	3.5	3.1	8.7	8.7	2.4	3.8	0.2

^zData are means for two replications, two harvests, two locations, and six fruits.

^yMean of ratings for taste, seedcell, placental hollows, and carpel separation.

^xMean of ratings for shriveling, fruit yellowing, and fruit disease.

^wTraits rated subjectively on a 1 to 9 scale (1–3 = poor, 4–6 = intermediate, 7–9 = excellent).

^vTraits rated subjectively on a 0 to 9 scale (0 = none, 1–3 = slight, 4–6 = moderate, 7–9 = severe).

^{ns}Nonsignificant.

were PI 379284, PI 339241, PI 414159, PI 422177, 'Regal' (check), PI 109483, Addis (check), PI 285603, PI 257486, and 'Calypso' (check), and the cultigen with the highest percentage of loss was PI 368553. The cultigens with the least degree of fruit shriveling during storage were 'Dasher II' (check), 'Sprint 440' (check), 'Texas Long', PI 390255, PI 432870, 'Pacer', PI 419078, PI 390247, PI 321011, and PI 414158, and those with the greatest degree of fruit shriveling were PI 368553, PI 183127, PI 432882, 'Stono', PI 432874, and PI 357864.

Retest study. No significant differences were detected between the two harvest dates and the two storage locations for the 20 cultigens tested in the study (Table 2). However, differences among cultigens were greater at 14 than at 7 d after harvest. Therefore, data are reported as means over two locations at 14 d after harvest.

The traits of greatest value in distinguishing keeping ability were ratings for shriveling and fruit yellowing, based on their low cv and high range/LSD (Table 2). Differences in all other traits measured were inconsistent or were not statistically significant. Cultigens with the best keeping ability (based on damage index) were all slicers: 'Dasher II', 'Marketmore 76', and 'Poinsett 76' (Table 2). The worst cultigens were 'Producer' (an obsolete cultivar) and 'Wis. SMR 18' (a black-spined cultivar).

In general, the tough skin of modern slicing cultigens and the white-spine trait of most new cultigens contributed to superior keeping ability. However, there were differences in keeping ability among the thin-skinned, white-spined cultigens (Table 2). 'Regal' was one of the best and 'Producer' was one of the worst for keeping ability. These two cultigens would make good check lines (positive and negative checks) for future tests of keeping ability among thin-skinned cultigens.

Other traits were too variable to provide significant differences among cultigens. Different sets of fruits had to be measured after 0, 7, and 14 d of storage, since the fruit were cut for evaluation of seedcell wateriness, placental hollow, carpel separation, and taste. Future studies could be done using the same fruits if seedcell wateriness, placental hollows, carpel separation, and taste were not evaluated. Since

the cultigens did not differ for those quality traits, they could be ignored in favor of obtaining better data for weight loss. Negative values for percentage of loss of fruit weight and firmness were a result of sampling error (Table 2). If a nondestructive test were conducted, firmness after 14 d would have to be used instead of percentage of loss in firmness, since no initial measurement for fruit firmness can be made (to calculate the percentage of loss in firmness) without damaging the fruits.

Differences between the cultigens per se and their hybrids were nonsignificant for shriveling and fruit yellowing of PI 220171 and for fruit shriveling of PI 422177. However, differences for fruit yellowing between the hybrids and cultigens per se for PI 422177 were significant (Table 2).

Future studies should examine more closely the association between skin toughness, spine color, and keeping ability. Keeping ability should be routinely measured on potential new cultivars by measuring weight loss, firmness, degree of shriveling, and fruit yellowing after storage for 14 d under uniform conditions. Check lines could include 'Marketmore 76', 'Regal', 'Wis. SMR 18', and 'Producer'.

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