Diversity of Fruit Quality Characteristics in *Capsicum frutescens*

Robert L. Jarret¹

USDA/ARS/PGRCU, 1109 Experiment Street, Griffin, GA 30224

Elizabeth Baldwin

USDA/ARS/CSPL, 600 Avenue NW, Winter Haven, FL 33881

Brian Perkins, Rod Bushway, and Kelly Guthrie

Department of Food Science and Human Nutrition, University of Maine, Orono, ME 04469

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Abstract. Fruit of 40 genotypes of *Capsicum frutescens* L. from the US Department of Agriculture/Agricultural Research Service *Capsicum* germplasm collection were analyzed for a variety of fruit quality parameters, including fruit size, weight, and concentrations of capsaicinoids, sucrose, glucose, fructose, malic acid, and total acid equivalents. Fruit weight ranged from 0.23 g fresh weight to 4.04 g fresh weight (average 1.05g). Fruit length/width ranged from 1 to 8.0 (average, 3.61). Capsaicin concentrations ranged from 34 to 350 mg·100 g⁻¹ fresh weight (average, 135 mg·100 g⁻¹ fresh weight). Sucrose concentrations ranged from 0.28 to 1.0 g·100 g⁻¹ (average, 0.6 g·100 g⁻¹ fresh weight). Total sugar extracts ranged from 0.73% to 2.6% (average, 1.55%). Malic acid concentrations and total acid equivalents ranged from 0.62 to 2.29 g·100 g⁻¹ fresh weight (average, 2.07 g·100 g⁻¹ fresh weight) and 0.97 to 3.31 g·100 g⁻¹ (average, 1.87 g·100 g⁻¹) respectively. These data demonstrate an approximate 4 to 14-fold range in values for the characteristics examined, suggesting the presence of sufficient variability for these traits within this species to support the development of germplasm enhanced for specific or multiple fruit quality attributes.

Capsicum frutescens L. is one of the five cultivated species in the genus *Capsicum* (Solanaceae) (Heiser and Pickersgill, 1969) and is closely related to *C. chinense* Jacq. (Baral and Bosland, 2004; Eshbaugh, 1976). Before Columbus, the neotropical range of *C. frutescens* extended from the Caribbean through northern South America (D'Arcy and Eshbaugh, 1974; Heiser and Smith, 1953). Numerous local land races of *C. frutescens* are cultivated in tropical and subtropical regions of the world (Heiser and Smith, 1953). The plants of *C. frutescens* are typically upright with one or sometimes two flowers per node, with green or greenish white corollas. Calyx teeth and a calyx constriction are lacking in *C. frutescens*. Fruit are typically upright, soft, and deciduous (D'Arcy and Eshbaugh, 1974).

C. frutescens is best known as the origin of the Tabasco variety of pepper, which has been grown commercially in the United States since the 1840s for the production of Tabasco sauce (DeWitt and Bosland, 1996). This variety, originally introduced to Louisiana from Mexico, was replaced in the 1970s by a tobacco etch virus-resistant cultivar (Greenleaf et al., 1970). Despite its

economic significance, improvements in commercially cultivated varieties of *C. frutescens* have occurred largely as a result of human selection within existing varieties, and limited information is available in the scientific literature regarding variability for agronomic or horticultural traits within the gene pool. Smith and Heiser (1957) did note that this species is much less variable than the other cultivated species in the genus. DeWitt and Bosland (1996) also noted that variability within *C. frutescens* for fruit shape, size, and color was more limited than within the more widely cultivated species *C. annum*, *C. baccatum* L., and *C. chinense*, possibly as a result of less intense human selection within *C. frutescens*. In addition to its culinary uses, *C. frutescens* is a source of saponin and other compounds that are being evaluated as natural fungicides (Duke et al., 2003).

Pungency is a key characteristic associated with members of the genus *Capsicum*. It is also an important fruit quality attribute. The degree of pungency in *Capsicum* fruit is proportional to the combined concentrations of the various vanillyl amides that represent capsaicinoids (Suzuki and Iwai, 1984). Pungency values for *Capsicum* sp. fruit can range from 0 to 300,000 SHUs (DeWitt and Bosland, 1993) or more (Mathus et al., 2000). Zewdie and Bosland (2000a) examined the capsaicinoid concentrations in 10 accessions of *C. frutescens*. Within these, capsaicinoid and dihydrocapsaicin concentrations ranged

from 53.08 to 73.44 mg·100 g⁻¹ and from 20.34 to 38.59 mg·100 g⁻¹ fresh weight respectively. Other fruit quality attributes, including concentrations of sucrose, fructose, and glucose, also affect fruit quality. The attribute sweetness was shown to be correlated with concentrations of sucrose and glucose in mature red fruit of *C. annum* (Luning et al., 1994). The absence of sourness was similarly shown to be correlated with concentrations of various organic acids (Luning et al., 1994).

This study was undertaken to examine accessions of *C. frutescens* in the US Department of Agriculture/Agricultural Research Service *Capsicum* gene bank (Jarret et al., 1990) for variability of fruit composition attributes that might serve as the basis for efforts to enhance fruit quality.

Materials and Methods

Plant culture. Fifteen to 20 plants of each genotype (Table 1) were transplanted to and grown in the field on the Georgia Experiment Station campus (Griffin, Ga.) in May 2004. Plants received periodic fertilization and irrigation, as required. A minimum of 100 mature red fruit were collected from 10 plants per genotype in three consecutive harvests at 1-week intervals (total of 300 fruit). In each instance, fruit were harvested from throughout the plants to reduce the effect of fruit position on the concentrations of the compounds to be analyzed (Zewdie and Bosland, 2000b). Variability in moisture content among fruit of accessions was determined to be ≈2%. After harvest, fruit calyxes were removed and the fruit was counted, measured, weighed, and frozen at -20 °C for up to 2 weeks before extraction. Digital images of the plant materials used can be seen at www.ars-grin.gov.

Extraction of capsaicinoids. All 100 fruit from each sample were chopped into small (<2.5 mm³) pieces, and subsequently blended to a slurry using a commercial food processor. Five-gram aliquots of the fruit slurry were homogenized in 25 mL 100% MeOH for 3 min in a 50-mL centrifuge tube using a Tisumizer (Tekmar Corp., Cincinnati) homogenizer at speed setting 8. The homogenate was centrifuged at 15,000 rpm for 15 min at 20 °C, and the supernatant containing total capsaicinoids was filtered through a syringe-mounted 22-μm filter into amber vials and stored at -4 °C for up to 2 weeks before analysis.

Extraction of carbohydrates and organic acids. Ten grams of fruit slurry were added to 40 mL 80% EtOH and homogenized using a Tisumizer (Tekmar Corp.) homogenizer at speed setting 8 in a 250-mL beaker. The homogenate was covered with a watch glass and was heated to boiling, with occasional stirring for 15 min. The homogenate was transferred to a 250-mL centrifuge bottle and was centrifuged for 10 min at 5000 rpm at 25 °C. The supernatant was brought to a final volume of 50 mL with 80% EtOH. For high-performance liquid chromatography

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¹To whom reprint requests should be addressed; e-mail bjarret@ars-grin.gov

Table 1. Variation in fruit weight, length, width, and length/width among fruit of 40 accessions of *C. frutescens*.

ID no. ^z	Country of origin	Fruit weight (g) ^y	Fruit length (cm) ^y	Fruit width (cm) ^y	Length/width ^y
PI188479	Vanuatu	0.90 ± 0.36	3.0 ± 0.54	1.0 ± 0.21	3.0 ± 0.60
PI193470	Ethiopia	1.71 ± 0.59	5.0 ± 0.80	1.0 ± 0.19	5.0 ± 1.25
PI208738	Cuba	0.28 ± 0.09	1.5 ± 0.22	0.5 ± 0.09	3.0 ± 0.81
PI224431	Costa Rica	0.70 ± 0.28	2.5 ± 0.35	1.0 ± 0.20	2.5 ± 0.11
PI238055	Nicaragua	1.98 ± 0.71	4.5 ± 0.49	1.5 ± 0.21	3.0 ± 0.75
PI238057	Guatemala	0.85 ± 0.24	4.0 ± 0.80	0.8 ± 0.15	5.5 ± 1.43
PI238059	Guatemala	3.49 ± 1.53	7.0 ± 1.05	1.0 ± 0.18	7.0 ± 2.12
PI241675	Ecuador	0.33 ± 0.09	5.0 ± 0.60	1.0 ± 0.18	7.0 ± 2.00
PI257051	Colombia	0.54 ± 0.13	3.5 ± 0.63	0.5 ± 0.08	7.0 ± 1.61
PI260479	Peru	0.98 ± 0.21	1.5 ± 0.22	0.5 ± 0.12	3.0 ± 0.78
PI273427	United States	0.52 ± 0.08	2.0 ± 0.32	0.5 ± 0.10	4.0 ± 1.00
PI281346	India	0.18 ± 0.06	1.5 ± 0.21	0.5 ± 0.10	3.0 ± 0.72
PI281396	Mexico	0.82 ± 0.30	1.0 ± 0.14	0.8 ± 0.17	1.3 ± 0.39
PI355396	Ecuador	0.72 ± 0.21	2.0 ± 0.30	0.8 ± 0.16	2.7 ± 0.70
PI358811	Malaysia	0.88 ± 0.22	2.5 ± 0.30	1.0 ± 0.16	2.5 ± 0.57
PI368065	Malaysia	1.69 ± 0.43	3.0 ± 0.57	0.8 ± 0.19	4.0 ± 1.04
PI368070	Malaysia	0.48 ± 0.10	3.0 ± 0.54	0.8 ± 0.20	4.0 ± 1.16
PI368073	Malaysia	1.50 ± 0.31	4.0 ± 0.64	1.2 ± 0.23	3.2 ± 0.88
PI368077	Malaysia	0.30 ± 0.11	1.0 ± 0.20	0.5 ± 0.11	2.0 ± 0.58
PI368085	Malaysia	0.83 ± 0.24	2.0 ± 0.32	1.0 ± 0.18	2.0 ± 0.52
PI438667	Mexico	1.22 ± 0.34	5.0 ± 0.90	1.0 ± 0.21	5.0 ± 1.15
PI439491	Brazil	0.23 ± 0.09	1.5 ± 0.24	0.5 ± 0.11	3.0 ± 0.70
PI439494	Costa Rica	1.34 ± 0.37	3.0 ± 0.54	1.0 ± 0.21	3.0 ± 0.63
PI439502	Costa Rica	3.35 ± 0.97	8.5 ± 1.70	1.5 ± 0.28	5.7 ± 1.43
PI439509	Fiji	0.52 ± 0.15	3.0 ± 0.51	0.8 ± 0.18	3.0 ± 0.81
PI439523	United Kingdom	0.95 ± 0.23	3.0 ± 0.60	0.8 ± 0.16	4.0 ± 0.96
PI441646	Brazil	0.23 ± 0.05	1.5 ± 0.24	0.5 ± 0.11	3.0 ± 0.62
PI543203	Bolivia	0.83 ± 0.25	3.0 ± 0.39	0.5 ± 0.13	6.0 ± 1.71
PI585254	Ecuador	0.35 ± 0.06	2.0 ± 0.28	0.5 ± 0.10	4.0 ± 0.99
PI585255	Ecuador	0.70 ± 0.19	2.0 ± 0.34	0.8 ± 0.12	2.7 ± 0.64
PI585256	Ecuador	1.32 ± 0.29	1.5 ± 0.33	1.5 ± 0.39	1.0 ± 0.27
PI593614	Philippines	0.40 ± 0.10	2.0 ± 0.42	0.5 ± 0.12	4.0 ± 1.13
PI593615	Mexico	1.17 ± 0.36	4.5 ± 0.81	1.0 ± 0.26	4.5 ± 1.23
PI594961	Guatemala	2.00 ± 0.56	7.0 ± 1.12	1.5 ± 0.31	4.7 ± 1.16
PI631139	Guatemala	0.52 ± 0.09	1.6 ± 0.30	1.0 ± 0.25	1.5 ± 0.39
PI631142	Guatemala	0.58 ± 0.19	2.0 ± 0.30	0.8 ± 0.23	2.7 ± 0.75
GRIF9315	Costa Rica	4.04 ± 1.33	12.0 ± 2.28	1.5 ± 0.37	8.0 ± 1.92
GRIF9319	Costa Rica	0.67 ± 0.25	3.0 ± 0.54	1.0 ± 0.20	3.0 ± 0.69
GRIF9323	Costa Rica	0.90 ± 0.31	2.0 ± 0.46	1.0 ± 0.17	2.0 ± 0.56
GRIF9339	Colombia	1.17 ± 0.32	2.0 ± 0.38	1.5 ± 0.24	1.3 ± 0.39

^zPlant introduction (PI) numbers unless noted otherwise.^yMean ± SD.

(HPLC) analysis, aliquots of this preparation were filtered sequentially through a preprepared Sep-Pak Plus C18 cartridge filter (Waters Corp., Milford, Mass.) and a 0.45- μ m syringe filter. Filtrates were stored in amber vials for up to 2 weeks at -20°C before analysis.

Analysis of capsaicinoids, carbohydrates, and organic acids. Capsaicin and dihydrocapsaicin were analyzed using HPLC as described previously (Jarret et al., 2003; Perkins et al., 2002). HPLC analysis of sugars was conducted as described by Baldwin et al. (1991). Individual sugars were analyzed by injecting 20 μ L extract filtrate on a Sugar Pak column at 90°C (Waters, Millipore Corp., Milford, Mass.) with a mobile phase of 0.0001 N methylenediamine tetraacetic acid disodium–calcium salt (CaEDTA), a flow rate of 0.5 mL·min⁻¹, and a refractive index detector (Agilent 1100 series; Agilent Technologies, Palo Alto, Calif.).

HPLC analysis of acids was conducted by injecting 20 μ L extract filtrate on a Thermo-Finnigan SpectraSytem UV6000UL (Thermo Electron Corp., San Jose, Calif.) with a Prevail Organic Acid column at 35°C (Alltech, Deerfield, Ill.), a mobile phase of 0.1N

H₂SO₄, a flow rate of 0.2 mL·min⁻¹, and a photo diode array (Thermo Electron Corp.) spectrophotometric detector at 210 nm.

Results and Discussion

Fruit size and shape were highly variable in *C. frutescens* (Table 1). Fruit weight averaged 1.05 g fresh weight with a range of 0.18 g fresh weight (PI 281346) to 4.04 g fresh weight (GRIF 9315) with an average of 1.05 g fresh weight. Zewdie and Zeven (1997) noted a 5.5-fold variation in fruit weight among 67 pungent varieties of *C. annuum* from Yugoslavia. We observed that fruit length varied from 1 cm (PI 368077 and PI 281396) to 8.5 cm (PI 439502). Most fruit were clearly elongate. However, the fruit length-to-width ratio varied from 1.0 (PI 585256) to 7 (PI 238059) with an average of 3.6.

Total capsaicinoids (capsaicin plus dihydrocapsaicin) content among the *C. frutescens* accessions varied by approximately ninefold from 53 (PI 439502) to 456 (PI 241675) mg/100 g fresh weight (Table 2). Values for the individual capsaicinoids (capsaicin and dihydrocapsaicin) ranged from

35 (PI 439502) to 350 (PI 241675) mg/100 g fresh weight and 18.5 (PI 439502) to 105 (PI 241675) mg/100 g fresh weight respectively. However, the ratio of capsaicin to dihydrocapsaicin averaged 2.94 and ranged from 0.94 (PI 594961) to 7.05 (PI 543203). Zewdie and Bosland (2001) noted an average capsaicin-to-dihydrocapsaicin ratio of 2:1 among 10 accessions of *C. frutescens*. Although capsaicin is typically the predominant capsaicinoid in hot peppers, the ratio of capsaicin to dihydrocapsaicin can vary substantially within and among species (Zewdie and Bosland, 2001). The individual capsaicinoids vary in their sensory properties (Krajewska and Powers, 1988), thus affecting the overall taste and degree of pungency. In addition to large genotypic effects on pungency, a portion of the variability in the observed capsaicinoid values may reflect the relative proportions of placental tissue to the total fruit mass, stage of maturation (Contreras–Padilla and Yahia, 1998), and local environment (Harvell and Bosland, 1997). As reported by Iwai et al. (1979), capsaicinoid synthesis and accumulation are restricted to the placental tissues.

Table 2. Variation in fruit concentrations of capsaicin (CAP), dihydrocapsaicin (DHC), and total capsaicinoids (TC) in milligrams per 100 g fresh weight, and the ratio of capsaicin to dihydrocapsaicin (C/D) in 40 genotypes of *C. frutescens*.

ID no. ^z	CAP ^y	DHC ^y	TC ^y	C/D
PI188479	121.9 ± 7.1	52.2 ± 3.4	174.1 ± 10.5	2.3
PI193470	60.8 ± 4.2	36.0 ± 2.1	96.8 ± 6.3	1.7
PI208738	272.4 ± 11.3	94.6 ± 4.1	367.1 ± 15.4	2.9
PI224431	71.3 ± 2.9	37.5 ± 2.3	108.8 ± 5.2	1.9
PI238055	95.8 ± 3.4	38.9 ± 3.2	134.7 ± 6.6	2.5
PI238057	124.1 ± 4.6	59.0 ± 2.9	183.1 ± 7.5	2.1
PI238059	64.2 ± 2.7	28.3 ± 1.5	92.5 ± 4.2	2.3
PI241675	351.6 ± 16.0	105.1 ± 3.3	456.7 ± 19.3	3.3
PI257051	166.6 ± 6.7	42.6 ± 3.8	209.3 ± 10.5	3.9
PI260479	312.8 ± 12.2	78.8 ± 5.2	391.6 ± 17.4	4.0
PI273427	100.6 ± 4.1	29.8 ± 2.2	130.3 ± 6.3	3.4
PI281346	114.3 ± 4.9	31.2 ± 1.5	145.5 ± 6.4	3.7
PI281396	110.9 ± 3.8	28.9 ± 1.4	139.8 ± 5.2	3.8
PI355396	78.9 ± 2.9	24.1 ± 1.5	102.9 ± 4.4	3.3
PI358811	88.4 ± 3.6	28.8 ± 1.7	91.3 ± 5.3	3.1
PI368065	162.1 ± 5.1	41.9 ± 1.8	204.0 ± 6.9	3.9
PI368070	157.3 ± 5.5	49.4 ± 2.1	206.7 ± 7.6	3.2
PI368073	84.9 ± 4.1	33.8 ± 1.9	118.7 ± 6.0	2.5
PI368077	97.4 ± 3.9	29.5 ± 1.6	126.9 ± 5.5	3.3
PI368085	115.8 ± 3.7	52.1 ± 2.5	167.9 ± 6.2	2.2
PI438667	145.5 ± 4.6	49.1 ± 2.1	194.6 ± 6.7	2.9
PI439491	231.6 ± 8.8	59.9 ± 2.1	291.5 ± 10.9	3.9
PI439494	87.5 ± 2.3	36.6 ± 1.2	124.0 ± 3.5	2.4
PI439502	34.9 ± 1.6	18.5 ± 0.9	53.5 ± 2.5	1.9
PI439509	216.7 ± 7.7	5.1 ± 3.3	281.8 ± 11.0	3.3
PI439523	112.5 ± 3.8	49.6 ± 2.1	162.1 ± 5.9	2.3
PI441646	317.6 ± 10.1	80.5 ± 3.9	398.2 ± 14.0	3.9
PI543203	174.4 ± 6.1	24.7 ± 1.0	199.1 ± 7.1	7.0
PI585254	130.2 ± 3.7	42.2 ± 1.7	172.3 ± 5.4	3.1
PI585255	208.9 ± 6.7	83.8 ± 2.2	292.8 ± 8.9	2.5
PI585256	84.2 ± 3.4	30.5 ± 1.0	114.8 ± 4.4	2.7
PI593614	161.3 ± 3.7	44.0 ± 1.4	205.4 ± 5.1	3.6
PI593615	91.5 ± 3.8	53.4 ± 2.2	144.9 ± 6.0	1.7
PI594961	45.4 ± 2.3	48.5 ± 2.1	93 ± 94.4	0.9
PI631139	160.2 ± 3.9	50.9 ± 2.5	211.1 ± 6.4	3.1
PI631142	9.2 ± 3.0	23.4 ± 1.3	102.6 ± 4.3	3.4
GRIF9315	54.1 ± 4.2	36.5 ± 1.3	90.7 ± 5.5	1.5
GRIF9319	137.1 ± 6.7	40.5 ± 1.8	177.6 ± 8.5	3.4
GRIF9323	117.2 ± 4.8	38.2 ± 1.6	155.4 ± 6.4	3.1
GRIF9339	67.7 ± 2.7	44.0 ± 1.7	111.7 ± 4.4	1.5

^zPI numbers unless noted otherwise.

^yMean ± SD.

Sucrose concentrations in fruit homogenates ranged from 0.28 (PI 543203) to 1.0 (PI 439509) g/100 g fresh weight with an average of 0.6 g/100 g fresh weight (Table 3). Glucose and fructose concentrations ranged from 0.43 (PI 358811) to 2.78 (PI 238055) g/100 g fresh weight and 0.63 (PI 631142) to 3.48 (PI 543203) g/100 g fresh weight respectively. Concentrations of total sugars were highest in GRIF 9315 (6.84 g/100 g fresh weight) and lowest (1.84 g/100 g fresh weight) in PI358811 and PI631142. These values are in general agreement with those reported by Luning et al. (1994) and Lopez-Hernandez et al. (1996), who demonstrated that concentrations of these sugars, and dry matter content, were related to the attribute sweetness in fully mature fruit of *C. annuum*.

Concentrations of organic acids were shown to be negatively correlated with sourness in mature fruit of *C. annuum* cvs. (Luning et al., 1994). Among the *C. frutescens* accessions examined, malic acid concentrations ranged from 0.62 (PI 238059) to 2.29 (PI 439494) g/100 g fresh weight with an average of 1.61 g/100 g fresh weight (Table 3). Total acid equivalents ranged from 0.86

(PI 631142) to 3.31 (PI 543203) with an average of 1.85.

Conclusion

Although a variety of compounds are known to affect the flavor (sweetness, sourness, pungency, etc.) and health-promoting benefits (vitamins, antioxidants, minerals, etc.) of pepper (*Capsicum* spp.) fruit, the scientific literature contains relatively little information on the extent of variability within the *Capsicum* germplasm for these characteristics. Information on fruit quality attributes can facilitate the development of varieties specifically enhanced for these characteristics by identifying genotypes to serve as potential parents in breeding programs, or for use in related research. The data reported here suggest that sufficient variability for fruit quality characteristic exists within the *C. frutescens* germplasm to support the development of varieties with specific flavor attributes.

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Table 3. Variation (mean $\pm$ sd) in fruit concentrations of sucrose (S), glucose (G), fructose (F), malic acid (MA), and total acid equivalents (TAE) in 40 genotypes of *C. frutescens*.

ID no. ^z	S (g/100 g fresh weight)	G (g/100 g fresh weight)	F (g/100 g fresh weight)	MA (g/100 g fresh weight)	TAE (%)
PI188479	0.45 $\pm$ 0.004	2.13 $\pm$ 0.17	2.00 $\pm$ 0.18	2.07 $\pm$ 0.12	2.19 $\pm$ 0.08
PI193470	0.78 $\pm$ 0.022	1.95 $\pm$ 0.19	2.28 $\pm$ 0.16	0.94 $\pm$ 0.06	2.46 $\pm$ 0.13
PI208738	0.68 $\pm$ 0.016	1.08 $\pm$ 0.10	1.10 $\pm$ 0.04	1.96 $\pm$ 0.05	1.35 $\pm$ 0.08
PI224431	0.45 $\pm$ 0.011	0.88 $\pm$ 0.07	0.80 $\pm$ 0.04	1.90 $\pm$ 0.10	0.99 $\pm$ 0.10
PI238055	0.58 $\pm$ 0.012	2.78 $\pm$ 0.16	2.40 $\pm$ 0.15	1.62 $\pm$ 0.09	2.71 $\pm$ 0.16
PI238057	0.68 $\pm$ 0.016	2.48 $\pm$ 0.17	2.33 $\pm$ 0.13	1.87 $\pm$ 0.13	2.61 $\pm$ 0.12
PI238059	0.43 $\pm$ 0.013	1.97 $\pm$ 0.12	2.35 $\pm$ 0.13	0.62 $\pm$ 0.08	2.38 $\pm$ 0.17
PI241675	0.45 $\pm$ 0.011	1.25 $\pm$ 0.10	1.35 $\pm$ 0.09	1.51 $\pm$ 0.07	1.48 $\pm$ 0.11
PI257051	0.55 $\pm$ 0.012	0.88 $\pm$ 0.04	1.10 $\pm$ 0.06	1.81 $\pm$ 0.08	1.24 $\pm$ 0.07
PI260479	0.70 $\pm$ 0.019	1.00 $\pm$ 0.07	1.15 $\pm$ 0.08	1.52 $\pm$ 0.08	1.37 $\pm$ 0.08
PI273427	0.65 $\pm$ 0.012	1.15 $\pm$ 0.06	1.30 $\pm$ 0.08	1.31 $\pm$ 0.05	1.50 $\pm$ 0.10
PI281346	0.85 $\pm$ 0.013	1.15 $\pm$ 0.08	1.03 $\pm$ 0.07	0.98 $\pm$ 0.07	1.39 $\pm$ 0.09
PI281396	0.75 $\pm$ 0.015	1.65 $\pm$ 0.07	1.58 $\pm$ 0.11	1.90 $\pm$ 0.08	1.88 $\pm$ 0.06
PI355396	0.63 $\pm$ 0.011	1.68 $\pm$ 0.09	1.73 $\pm$ 0.20	2.01 $\pm$ 0.10	1.94 $\pm$ 0.10
PI358811	0.43 $\pm$ 0.012	0.43 $\pm$ 0.02	0.98 $\pm$ 0.50	1.65 $\pm$ 0.11	0.97 $\pm$ 0.03
PI368065	0.53 $\pm$ 0.019	0.75 $\pm$ 0.03	1.08 $\pm$ 0.05	1.57 $\pm$ 0.09	1.18 $\pm$ 0.04
PI368070	0.50 $\pm$ 0.008	0.95 $\pm$ 0.03	1.03 $\pm$ 0.05	1.70 $\pm$ 0.06	1.19 $\pm$ 0.08
PI368073	0.53 $\pm$ 0.012	1.55 $\pm$ 0.08	1.60 $\pm$ 0.08	1.75 $\pm$ 0.06	1.78 $\pm$ 0.09
PI368077	0.60 $\pm$ 0.021	1.15 $\pm$ 0.09	1.10 $\pm$ 0.06	1.93 $\pm$ 0.08	1.34 $\pm$ 0.05
PI368085	0.58 $\pm$ 0.014	1.68 $\pm$ 0.10	1.68 $\pm$ 0.06	2.29 $\pm$ 0.06	1.88 $\pm$ 0.09
PI438667	0.53 $\pm$ 0.117	2.23 $\pm$ 0.18	2.13 $\pm$ 0.12	1.72 $\pm$ 0.10	2.34 $\pm$ 0.11
PI439491	0.83 $\pm$ 0.024	1.13 $\pm$ 0.04	1.33 $\pm$ 0.10	1.61 $\pm$ 0.07	1.58 $\pm$ 0.09
PI439494	0.50 $\pm$ 0.012	1.85 $\pm$ 0.14	1.95 $\pm$ 0.13	2.29 $\pm$ 0.11	2.10 $\pm$ 0.08
PI439502	0.40 $\pm$ 0.006	2.87 $\pm$ 0.25	2.83 $\pm$ 0.16	1.20 $\pm$ 0.08	2.97 $\pm$ 0.17
PI439509	1.00 $\pm$ 0.045	1.18 $\pm$ 0.15	1.30 $\pm$ 0.07	1.67 $\pm$ 0.06	1.65 $\pm$ 0.06
PI439523	0.38 $\pm$ 0.009	1.95 $\pm$ 0.15	1.88 $\pm$ 0.13	1.93 $\pm$ 0.08	2.02 $\pm$ 0.08
PI441646	0.85 $\pm$ 0.018	1.28 $\pm$ 0.06	1.40 $\pm$ 0.10	1.51 $\pm$ 0.07	1.69 $\pm$ 0.10
PI543203	0.28 $\pm$ 0.003	2.70 $\pm$ 0.21	3.48 $\pm$ 0.20	0.74 $\pm$ 0.05	3.31 $\pm$ 0.15
PI585254	0.85 $\pm$ 0.022	1.20 $\pm$ 0.07	1.33 $\pm$ 0.07	1.77 $\pm$ 0.08	1.61 $\pm$ 0.09
PI585255	0.60 $\pm$ 0.016	1.33 $\pm$ 0.09	1.40 $\pm$ 0.08	1.45 $\pm$ 0.08	1.60 $\pm$ 0.11
PI585256	0.70 $\pm$ 0.016	2.58 $\pm$ 0.20	2.13 $\pm$ 0.12	1.66 $\pm$ 0.05	2.51 $\pm$ 0.11
PI593614	0.73 $\pm$ 0.013	1.05 $\pm$ 0.06	1.15 $\pm$ 0.07	1.30 $\pm$ 0.07	1.40 $\pm$ 0.07
PI593615	0.63 $\pm$ 0.011	1.68 $\pm$ 0.07	1.73 $\pm$ 0.13	1.80 $\pm$ 0.10	1.94 $\pm$ 0.07
PI594961	0.43 $\pm$ 0.008	2.37 $\pm$ 0.18	2.48 $\pm$ 0.14	1.03 $\pm$ 0.05	2.59 $\pm$ 0.13
PI631139	0.58 $\pm$ 0.020	0.85 $\pm$ 0.07	1.40 $\pm$ 0.10	1.63 $\pm$ 0.05	1.45 $\pm$ 0.09
PI631142	0.68 $\pm$ 0.013	0.53 $\pm$ 0.03	0.63 $\pm$ 0.03	1.43 $\pm$ 0.06	0.86 $\pm$ 0.03
GRIF9315	0.58 $\pm$ 0.017	3.18 $\pm$ 0.28	3.08 $\pm$ 0.21	1.63 $\pm$ 0.10	3.30 $\pm$ 0.13
GRIF9319	0.60 $\pm$ 0.013	1.28 $\pm$ 0.08	1.78 $\pm$ 0.16	1.74 $\pm$ 0.09	1.85 $\pm$ 0.07
GRIF9323	0.50 $\pm$ 0.009	1.20 $\pm$ 0.06	1.78 $\pm$ 0.15	1.76 $\pm$ 0.13	1.78 $\pm$ 0.07
GRIF9339	0.63 $\pm$ 0.030	2.23 $\pm$ 0.16	2.65 $\pm$ 0.14	1.41 $\pm$ 0.08	2.74 $\pm$ 0.10

^zPI numbers unless noted otherwise.

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