Determination of Fruit Sampling Location for Quality Measurements in Melon (*Cucumis melo* L.)

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Introduction. Fruit quality assessment and characterization is an important objective in many melon improvement programs. There are several simply inherited genes that control melon fruit ripening, shape and flesh color. Examples of such fruit quality genes are flesh color (*gf*), fruit abscission (*Al-3*, *Al-4*), mottled ring pattern (*Mt-2*), pentamerous (*p*; five carpels), presence of vein tracts on the rind (*s*), mealy flesh texture-2 (*Me-2*), sour taste (*So*), empty cavity (*Ec*), and white testa (*Wt*) (Pitrat., 2002). Possible linkages were found between *wt-2* and *s-3*, and between *Me-2* and *Ec* (Perin et al., 1999).

Our laboratories have been interested in collaborative mapping of yield components in a cross between a line designated as USDA 846 and 'Top Mark'. USDA 846 was derived from mating between an exotic accession obtained from Costa Rica and 'Top Mark'. Subsequent backcrossing (BC_2 to 'Top Mark') and selfing (S_4) of progeny from this initial mating were selected for fruit size and number, multiple lateral branching, and early crown-setting ability and self-pollinated to produce USDA 846. The fruit of line USDA 846 does not fit into a defined market class, having unique epidermal and mesocarp fruit characteristics. We are interested in improving the fruit quality of lines derived from USDA 846, and thus are developing strategies to evaluate specific fruit characteristics for selection and genetic mapping. We report herein the assessment of different fruit sampling locations for the determination of fruit firmness and total soluble solids in commercial hybrids, experimental lines, and a hybrid between USDA 846 and 'Top Mark' in two growing locations.

Materials and Methods. Five fruits of experimental melon lines (USDA 3022, USDA 3157) and cultivars ('Top Mark', 'Sol Real') were selected from a replicated melon trial (plants 30 cm apart in rows and rows placed on 2.1 m centers) in El Centro, Calif. (June 2003) for examination of fruit firmness and total soluble solids concentration at no-slip, and half- and full-slip fruit maturity. In Hancock, Wisc. (September 2003), plants were grown under the same spacing, and three to five fruits from 'Esteem', 'Top Mark', 'Sol Dorado', and the USDA experimental hybrid 846 x Top Mark were sampled from a replicated yield trial for soluble solid concentration and firmness analysis at half- and full-slip maturity.

In California, 10 fruits from each entry were analyzed for total soluble solids evaluation using a digital BRIX refractometer (Model DR103L, QA Supplies, Norfolk, Va., USA) and firmness in using a fruit pressure tester, i.e., penetrometer, Model# FT 011, Effigi, Alfonsine, Italy. Five fruit were cut in transverse section and five were cut longitudinally, samples (~ 3 cm^3) were taken from each fruit at specific locations (Figure 1). Based on results from the California location, sampling of three to five fruits at half- and full-slip maturity were performed using transverse sections only at Hancock (Figure 1, Panel B).

Results and Discussion. *El Centro.* Means and standard deviations for firmness and soluble solids concentration were variable and depended on relative maturity and position of sampling (Table 1). The mesocarps of fruits that did not detach from the stem, i.e., no slip (NS), were firmer than those at half-slip maturity, which were firmer than those at full maturity, i.e., full-slip. Standard deviations from the mean were generally lower in fruits sampled in transverse section when compared to those sampled in longitudinal section. Thus, sampling of fruit at Hancock was restricted to transverse sections at half- or full-slip maturity. After initial sampling of fruits for soluble solid estimations it became clear that sampling at positions 1 and 3 in transverse section or 2 and 5 in longitudinal section provided the most consistent results, i.e., mean and SD. Thus, only these measurements are reported herein. Soluble

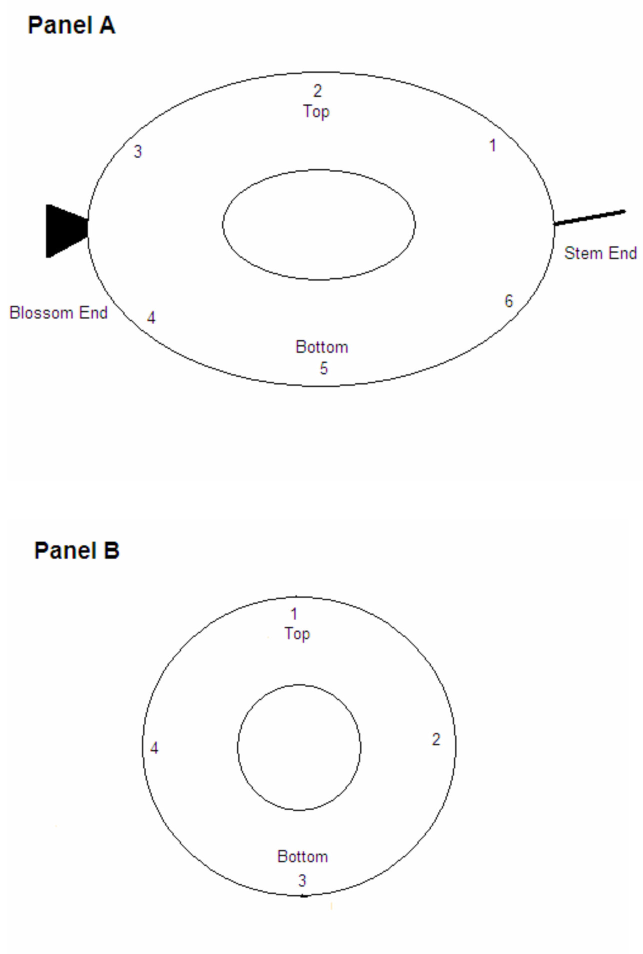

Figure 1: Diagrammatic representation of longitudinal (Panel A) and transverse (Panel B) sampling locations of melon (*Cucumis melo* L.) for mesocarp sugar content and pressure analysis (without epidermis).

Table 1. Firmness and soluble solids concentration of melon fruit grown at El Centro, Calif. cut in horizontal and transverse section and sampled at different mesocarp locations according to Figure 1 (data for 3 or 5 fruit per entry).

		Fruit firmness (pressure to compress in lbs.)[2]								Soluble solids concentration (Brix)					
	Relative[1]	Sampling position								Sampling position					
Entry	maturity	1	2	3	4	5	6	Mean	SD[3]	1	2	3	5	Mean	SD
								Transverse section							
3022	HS[2]	6.0	6.6	5.5	5.0			5.8	0.7	11.7		9.9		10.8	1.3
	NS[3]	5.7	6.7	8.0	5.3			6.4	1.2	7.1		8.3		7.7	0.8
	NS	4.8	5.0	5.9	5.4			5.3	0.5	10.8		9.5		10.2	0.9
	NS	9.0	5.6	5.3	7.8			6.9	1.8	5.3		5.4		5.4	0.1
	NS	10.0	7.5	6.9	7.3			7.9	1.4	5.3		4.9		5.1	0.3
	Mean	7.1	6.3	6.3	6.2					8.0		7.6			
	SD	2.3	1.0	1.1	1.3					3.0		2.3			
3157	NS	8.0	9.8	8.0	6.4			8.1	1.4	6.9		6.9		6.9	0.0
	NS	5.9	6.7	5.8	5.8			6.1	0.4	8.2		7.3		7.8	0.6
	NS	9.1	9.6	10.0	10.0			9.7	0.4	4.7		5.1		4.9	0.3
	NS	9.0	8.6	8.7	8.2			8.6	0.3	7.0		6.3		6.7	0.5
	NS	7.5	7.9	7.5	8.0			7.7	0.3	8.5		7.9		8.2	0.4
	Mean	7.9	8.5	8.0	7.7					7.1		6.7			
	SD	1.3	1.3	1.5	1.7					1.5		1.1			
Top Mark	FS[4]	7.8	8.2	7.5	8.5			8.0	0.4	15.4		14.7		15.1	0.5
	FS	8.5	6.6	8.2	8.7			8.0	1.0	12.7		13.0		12.9	0.2
	FS	5.7	7.2	7.9	6.2			6.8	1.0	13.8		14.4		14.1	0.4
	HS	10.0	8.8	10.0	10.0			9.7	0.6	13.7		14.9		14.3	0.8
	HS	6.4	7.2	8.1	6.6			7.1	0.8	7.9		10.1		9.0	1.6
	Mean	8.3	7.6	6.7	8.7			8.0	7.5	12.7		13.4			
	SD	1.7	0.9	1.0	1.6					2.9		2.0			
Sol Real	FS	5.2	5.7	6.2	5.5			5.7	0.4	13.4		13.9		13.7	0.4
	FS	5.5	5.4	5.3	4.6			5.2	0.4	14.8		12.5		13.7	1.6
	FS	5.0	4.2	4.9	4.5			4.7	0.4	11.5		14.6		13.1	2.2
	Mean	5.2	5.1	5.5	4.9					13.2		13.7			
	SD	0.3	0.8	0.7	0.6					1.7		1.1			

(continued)

Table 1. continued.

		Fruit firmness (pressure to compress in lbs.)								Soluble solids concentration (Brix)					
		Sampling position								Sampling position					
Entry	Relative maturity	1	2	3	4	5	6	Mean	SD	1	2	3	5	Mean	SD
						Longitudinal section									
3022	HS	6.4	5.4	6.6	6.6	4.5	6.0	5.9	0.8		6.6		6.1	6.4	0.4
	NS	6.0	4.4	5.7	5.3	5.4	6.2	5.5	0.6		7.7		7.9	7.8	0.1
	NS	6.4	6.5	6.5	7.0	5.0	5.9	6.2	0.7		5.5		6.0	5.8	0.4
	NS	5.3	4.5	6.3	7.0	6.0	7.8	6.2	1.2		8.9		9.7	9.3	0.6
	NS	8.5	4.5	5.8	5.8	5.8	6.4	6.1	1.3		11.6		10.0	10.8	1.1
	Mean	6.5	5.1	6.2	6.3	5.3	6.5				8.1		7.9		
	SD	1.2	0.9	0.4	0.8	0.6	0.8				2.3		1.9		
3157	NS	7.6	8.4	8.6	6.9	8.7	9.7	6.8	3.1		6.7		7.1	6.9	0.3
	NS	10.2	5.5	5.0	7.0	8.5	8.0	6.5	2.7		7.8		7.0	7.4	0.6
	NS	8.6	5.4	6.2	8.5	9.4	10.0	6.9	2.3		8.3		7.4	7.9	0.6
	NS	8.0	4.7	5.6	6.8	9.4	7.6	6.2	2.3		7.7		7.4	7.6	0.2
	NS	9.0	7.0	10.0	10.0	8.0	9.6	7.7	2.9		7.1		7.5	7.3	0.3
	Mean	8.7	6.2	7.1	7.8	8.8	9.0				7.5		7.3		
	SD	1.0	1.5	2.1	1.4	0.6	1.1				0.6		0.2		
Top Mark	HS	6.0	7.7	5.4	7.6	7.3	7.5	5.8	2.6		11.9		12.4	12.2	0.4
	FS	9.6	8.5	6.8	7.6	8.0	7.0	6.9	3.0		13.4		11.0	12.2	1.7
	FS	7.5	7.0	6.2	9.5	6.7	7.4	6.3	2.9		13.8		12.3	13.1	1.1
	FS	10.0	6.1	6.9	10.0	9.8	8.6	7.2	3.7		7.4		8.8	8.1	1.0
	HS	8.5	8.5	8.2	9.0	8.0	7.0	7.1	3.4		14.0		13.3	13.7	0.5
	Mean	8.3	7.6	6.7	8.7	8.0	7.5				12.1		11.6		
	SD	1.6	1.0	1.0	1.1	1.2	0.7				2.8		1.7		
Sol Real	FS	6.4	5.0	5.0	5.2	4.4	5.5	4.4	2.1		13.2		11.8	12.5	1.0
	FS	6.8	5.2	5.8	5.7	4.8	5.9	4.8	2.3		15.2		13.9	14.6	0.9
	FS	5.9	5.0	5.8	5.5	4.9	6.5	4.5	2.2		13.5		15.1	14.3	1.1
	Mean	6.4	5.1	5.5	5.5	4.7	6.0				14.0		13.6		
	SD	0.5	0.1	0.5	0.3	0.3	0.5				1.1		1.7		

[1]HS = half-slip maturity reflects relative ease of detachment from fruit compared to full-slip maturity, NS = no-slip maturity indicates no tendency to detach from fruit, and FS = full-slip maturity reflects tendency to completely detach from fruit.
[2]Measurements taken with a penetrometer.
[3]SD = standard deviation.

Table 2. Firmness and soluble solids concentration of melon fruit grow at Hancock, Wisc. cut in horizontal and transverse section and sampled at different mesocarp locations according to Figure 1 (data for 3 or 5 fruit per entry).

		Fruit firmness Pressure to compress (lbs.)[2]						Soluble solids concentration (Brix)			
		Sampling position						Sampling position			
Entry	Relative[1] maturity	1	2	3	4	Mean	SD[3]	1	3	Mean	SD
Esteem	FS	3.5	4.2	4.2	3.6	3.9	0.4	6.5	8.2	7.4	1.2
	FS	4.0	4.2	4.7	4.2	4.3	0.3	6.9	6.5	6.7	0.3
	FS	3.8	3.5	3.6	3.8	3.7	0.2	6.9	6.7	6.8	0.1
	Mean	3.8	4.0	4.2	3.9			6.8	7.1		
	SD										
Top Mark	FS	6.0	5.9	6.1	6.1	6.0	0.1	8.4	9.2	8.8	0.6
	FS	6.2	7.2	6.8	6.9	6.8	0.4	9.4	8.9	9.2	0.4
	HS	6.4	6.2	7.7	6.6	6.7	0.7	8.8	9.5	9.2	0.5
	HS	7.5	7.6	6.8	7.7	7.4	0.4	6.5	6.9	6.7	0.3
	HS	5.5	5.4	5.0	6.6	5.6	0.7	6.5	6.1	6.3	0.3
	Mean	6.3	6.5	6.5	6.8			7.9	8.1		
	SD										
Sol Dorado	FS	1.5	1.2	1.2	1.6	1.4	0.2	8.2	8.4	0.3	0.3
	FS	2.0	2.0	1.8	2.0	2.0	0.1	8.0	7.0	7.5	0.7
	FS	1.9	2.0	1.3	1.9	1.8	0.3	6.9	6.0	6.5	0.6
	FS	2.2	2.0	1.3	1.9	1.9	0.4	7.5	7.8	7.7	0.2
	FS	2.4	2.3	2.4	2.9	2.5	0.3	9.0	5.7	7.4	2.3
	Mean	2.0	1.9	1.6	2.1			8.0	6.9		
	SD										
846 x Top Mark	FS	2.4	2.2	2.2	1.9	2.2	0.2	7.6	6.5	7.1	0.8
	FS	3.1	3.6	3.6	3.7	3.5	0.3	8.3	9.0	8.7	0.5
	FS	3.8	2.9	2.5	2.5	2.9	0.6	10.0	8.9	9.5	0.8
	HS	7.7	5.7	6.9	6.9	6.8	0.8	5.3	6.8	6.1	1.1
	HS	--	10.0	7.5	7.2	8.2	1.5	7.9	6.4	7.2	1.1
	Mean	4.3	4.9	4.5	4.4			7.8	7.5		
	SD										

[1] HS = half-slip maturity reflects relative ease of detachment from fruit compared to full-slip maturity, and FS = full-slip maturity reflects tendency to completely detach from fruit.
[2] Measurements taken with penetrometer.
[3] SD = standard deviation.

solids concentration varied with maturity (half- and full-slip having relatively high values compared to NS) and the hybrids examined. Standard deviations were highest in half- and full-slip fruits.

Hancock. Mean fruit firmness values varied (1.4 to 7.4) among the hybrids examined and standard deviations were relatively low ranging from 0.1 to 1.5 (Table 2). In contrast, soluble solid concentration values were less variable (6.1 to 9.5) and standard deviations were remarkably high ranging from 0.1 to 2.3 (Table 2).

These results indicate that fruit firmness may be a trait that, when measured under replication, could provide information for inheritance and genetic mapping studies. The precise estimation of total fruit soluble solids concentration is difficult, i.e., highly variable, and placement of this trait on a genetic map will likely require the measurement of fruit having similar maturity (half- or full-slip) and the examination of several fruit, perhaps as many as 10, from a replication. Studies of inheritance will likely require relatively high replication (perhaps 6) and multiple measurements of plants within a plot (perhaps 5-10).

Literature Cited

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