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Productivity and Quality Characteristics of Strawberry Cultivars Under Michigan Conditions

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Abstract

Eighteen strawberry cultivars were compared in a matted row system on a sandy loam soil in southwest Michigan in 1991 and 1992. The most productive cultivars were 'Honeoye,' 'Annapolis' and 'Lester' in the early season, 'Glooscap,' 'Settler' and 'Selkirk' in the mid season, and 'Allstar,' 'Kent,' 'Jewel' and 'Blomidon' in the late season. 'Lester' and 'Selkirk' rated relatively high in shelf-life characteristics. When whole berries were frozen then thawed, 'Lester,' 'Selkirk' and 'Allstar' rated highest in appearance.

Introduction

Strawberries are produced in Michigan for fresh sales through Pick-Your-Own marketing and retail outlets, and for processing, primarily as sliced berries in sugar or puree. Desired berry characteristics vary depending on the use. Durability and shelf life are of primary importance for fresh marketed berries, whereas freezing characteristics are important if berries are to be processed.

Strawberry cultivars currently important in Michigan were developed in breeding programs at the USDA in Maryland ('Allstar,' Earliglow,' 'Midway,' Redchief'), New York ('Honeoye,' 'Jewel') and Nova Scotia, Canada ('Kent'). These breeding programs and others continue to produce promising new cultivars. This study was conducted to evaluate the productivity, shelf life and freezing characteristics of recently released cultivars under Michigan conditions.

Materials and Methods

Eighteen strawberry cultivars were planted at the Southwest Michigan Research and Extension Center, Benton Harbor, Michigan in April, 1990. The soil was a Spinks loamy fine sand. Plants were spaced 0.4m apart in rows 1.5m apart, and managed in a matted row system (3). Plots were 4m long, and arranged in a completely randomized design with three replications. Buffer rows and row sections surrounded the entire planting.

Standard management practices were followed (3). Sprinkler irrigation was provided as required to supplement precipitation and protect flowers from spring freeze injury. Hand weeding and the herbicide DCPA were used to control weeds. Plants were covered with a 20 cm thick straw layer for winter protection from December to March. Fungicides were applied in the spring as needed to control fruit rots (one spray in 1991, three in 1992).

During the harvest season in 1991 and 1992, fruit were picked by hand in the morning every two to five days. Total fruit weight and weight per 25 berries were recorded on each picking. Berries were transported immediately in an air conditioned car to East Lansing, MI for shelf life and freezing evaluations.

Shelf life was compared within two groups of cultivars in 1991 (early to mid-season, mid-season to late) and three groups in 1992 (early, mid-season, late). A replication consisted of 600-800 g of intact, uniform ripe berries placed in two fiber 0.47 l containers on the day they were harvested. A total of four and six replicate samples were evaluated for shelf life in 1991 and 1992, respectively One to four

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replicate samples were collected for shelf life evaluations on a given harvest date, depending on quantity of fruit available. All fruit in a given replication was harvested on the same date and evaluated by the same individuals.

Berries were weighed and the visual appearance was rated by three to five individuals on a scale of 1 (extremely attractive with no defects) to 10 (completely unacceptable). Although individual evaluators varied most days, the same individuals rated all samples in one replication. Containers were then placed in cardboard flats, wrapped in loose plastic garbage bags, and maintained at 2C for two to five days. Flats were held at 18C for one additional day to simulate retail display, then evaluated. The post-storage appearance of each container was rated by the same procedure described above. Berries were again weight. Caps and moldy portions of berries were then removed with a knife, and re-weighed. The percent weight loss during storage, and the percent mold weight and cap weight after storage were then calculated.

Firmness was measured on 20 berries of each cultivar in 1991 using a prototype firmness meter that squeezed individual berries and recorded force (g) versus deformation (mm) (1). Measurements were made on 20 berries per cultivar on the day of harvest. Berries represented the average size for each cultivar, and were free from defects.

The freezing characteristics of fruit were compared within three separate groups of cultivars (early, mid-season, late) in 1991 and 1992. The cultivars within each group varied each year since adequate quantities of some were not available. Three to six replicate samples were evaluated in 1991 and four were tested in 1992. Each replication consisted of two 0.47 l subsamples of uniform berries. Berries were decapped with a knife, stored in 1.0 l, 0.051 mm thick, polyethylene (Zip-Lock) bags, in a -40C freezer, and evaluated within 2 months.

Frozen samples were assessed by allowing berries to thaw at 18C in 0.5 l plastic mesh containers. The visual appearance of berries was rated after they fully thawed using a scale of 1 to 10, with 1 = very appealing and structurally intact, 5 = generally acceptable but less appealing due to off-color, loss of glossiness or integrity, and 10 = very unappealing, integrity lost. Thawed berries and the juice that drained from berries were weighed. Berries and juice were then blended briefly to form a puree (1991) or minced in a food processor (1992). Three to five individuals tasted samples and rated

Table 1. Yield and average berry weight of strawberry cultivars at Benton Harbor, MI, 1991-92.

Cultivar	Yield (1000 kg/ha)			Berry weight (g)		
	1991	1992	Ave.	1991	1992	Ave.
Early Season						
Annapolis	11.4	13.4	12.4	15.3	12.0	13.7
Cornwallis	7.6	13.2	10.4	8.8	8.6	8.7
Earliglow	7.5	3.4	5.5	10.2	10.3	10.3
Honeoye	10.8	14.2	12.5	11.8	11.4	11.6
Lester	10.6	13.1	11.9	12.8	10.7	11.8
Redcoat	7.6	9.4	8.5	9.9	10.8	10.4
Veestar	7.7	9.7	8.7	10.5	9.4	10.5
LSD (0.05)	n.s.	4.7	3.0	1.4	1.8	1.2
Mid-Season						
Glooscap	12.9	15.5	14.2	12.8	12.4	12.7
Gov. Simcoe	7.9	10.1	9.0	11.8	12.8	12.3
Midway	8.2	7.0	7.6	11.6	8.6	10.1
Selkirk	10.2	10.9	10.6	10.8	14.3	12.6
Settler	10.2	11.1	10.7	14.8	12.7	13.8
LSD (0.05)	4.8	5.3	3.7	1.9	1.9	1.5
Late Seson						
Allstar	11.4	15.5	13.5	13.7	14.5	14.1
Blomidon	13.2	10.6	11.9	12.8	15.5	14.2
Jewell	10.8	13.1	12.0	11.9	14.8	13.4
Kent	10.3	15.6	13.0	14.2	13.0	13.6
Lateglow	7.5	8.3	7.9	13.4	13.4	13.4
Scotland	7.2	14.4	10.8	12.1	15.5	13.8
LSD (0.05)	3.2	4.8	2.7	1.4	2.2	n.s.

sweetness, sourness, strawberry-like flavor, flavor intensity and presence of any objectionable off-flavors (1991) or simply over-all flavor (1992). The same three to five tasters rated all cultivars within one replication, and individual ratings were averaged for each cultivar. One or two replications of frozen samples were assessed in one day.

Vegetative growth was assessed in June of 1991 and 1992. Vigor of each plot was rated visually on a scale of 1 (very weak plants with minimal growth) to 5 (extremely vigorous plants). The % of the plot area that was occupied with plants (% plant stand) was visually estimated as a measure of runner production.

Analysis of variance was conducted on all data. Fisher's LSD was used to separate means.

Table 2. Plant vigor and plant stand of strawberry cultivars at Benton Harbor, 1991-92.

Cultivar	Plant vigor[1]		Plant stand (%)[2]	
	1991	1992	1991	1992
Early Season				
Annapolis	4.2	5.0	98	100
Cornwallis	4.5	4.7	90	97
Earliglow	3.0	4.0	73	70
Honeoye	4.3	4.7	98	97
Lester	4.8	4.5	98	97
Redcoat	3.5	3.7	83	98
Veestar	3.6	3.0	90	87
LSD (0.05)	1.6	1.2	21	16
Mid-Season				
Glooscap	3.8	5.0	85	95
Gov. Simcoe	4.2	4.5	97	88
Midway	4.5	4.3	100	93
Selkirk	4.5	4.7	93	81
Settler	4.0	4.0	90	83
LSD (0.05)	n.s.	0.9	n.s.	n.s.
Late Season				
Allstar	5.0	4.7	100	97
Blomidon	4.5	4.7	93	95
Jewell	4.5	4.7	98	87
Kent	4.2	4.7	88	100
Lateglow	4.2	3.7	100	90
Scotland	4.2	5.0	83	100
LSD (0.05)	n.s.	1.1	n.s.	n.s.

[1]Visual rating from 1 (very weak, low vigor) to 5 (very vigorous).
[2]Estimated % of plot area occupied by plants.

Results and Discussion

The 1991 harvest season was relatively warm (ave daily temp. 21.3C) and short (31 May to 17 June). The 1992 season was slightly cooler (ave daily temp 17.7C), and longer in duration (9 June to 2 July). Average yields across all cultivars were higher in 1992 (11,600 kg/ha) than 1991 (9,600).

Berry yields and weight are compared for early, mid-season and late genotypes (Table 1). 'Honeoye,' 'Annapolis' and 'Lester' were the highest yielding early season types. These cultivars also tended to produce the largest berries. 'Glooscap,' 'Settler' and 'Selkirk' were the most productive mid-season varieties, and 'Allstar,'

Table 3. Shelf-life evaluation of strawberry cultivars at Benton Harbor, MI, 1991.

Cultivar	Pre-storage appearance[1]	Firmness (g/mm)	After storage	
			Appearance	Mold Weight (%)
Early to mid-season				
Annapolis	5.8	189	2.5	31
Earliglow	5.5	166	2.3	43
Honeoye	5.3	173	2.2	41
Lester	5.6	206	2.2	20
Redcoat	5.0	194	2.3	29
LSD (0.05)	n.s.	18	n.s.	10
Mid- to late-season				
Allstar	6.7	215	2.4	26
Blomidon	8.3	198	1.9	38
Glooscap	8.3	144	1.5	43
Gov. Simcoe	7.8	186	3.2	42
Jewel	8.2	207	1.6	68
Kent	8.5	180	1.1	43
Midway	5.5	160	1.2	51
Settler	8.2	194	1.2	64
LSD (0.05)	8.0	19	1.0	18

[1]Appearance rated on a scale of 1 (very unattractive) to 10 (extremely attractive).

Table 4. Shelf-life evaluation of strawberry cultivars at Benton Harbor, MI, 1992.

Cultivar	Pre-storage appearance[1]	After storage	
		Appearance	Mold Weight (%)
Early season			
Annapolis	5.9	5.4	22.9
Cornwallis	4.8	4.9	21.6
Earliglow	3.9	3.1	26.3
Honeoye	6.2	4.1	23.0
Lester	7.1	6.0	11.8
LSD (0.05)	3.3	1.2	6.8
Mid-season			
Glooscap	3.9	2.4	19.9
Gov. Simcoe	6.7	4.4	16.1
Midway	4.1	2.4	21.6
Redcoat	5.0	3.6	23.0
Selkirk	7.6	6.1	6.4
MDUS 5136	5.5	3.9	12.5
LSD (0.05)	1.8	1.2	7.5
Late season			
Allstar	5.5	3.2	13.0
Blomidon	5.7	3.8	16.2
Jewel	5.1	3.1	16.6
Kent	4.9	2.4	23.5
Lateglow	4.5	2.7	26.2
Settler	5.4	1.6	20.0
LSD (0.05)	n.s.	1.2	6.4

[1]Appearance rated on a scale of 1 (very unattractive) to 10 (extremely attractive).

'Kent,' 'Jewel' and 'Blomidon' the highest producing late varieties. 'Kent' and 'Honeoye' were very productive in earlier trials in the Midwest (2) and Colorado (4).

The vegetative growth (plant vigor, plant stand) was similar for most cultivars (Table 2). Cultivars rating lowest in plant vigor or plant stand were 'Earliglow' and 'Veestar' in the early group, and 'Lateglow' in the late group. These cultivars also tended to yield relatively low.

Relative shelf life was compared for two groups of cultivars in 1991 (Table 3) and three groups in 1992 (Table 4). The early to mid-season cultivars compared in 1991 rated similar in appearance before and after a storage period (Table 3). However, 'Lester' and 'Redcoat' developed less mold during storage than 'Earliglow' or 'Honeoye'. Of the mid- to late season cultivars compared in 1991, 'Governor Simcoe' and 'Allstar' maintained the most attractive appearance after storage. 'Kent,' 'Midway' and 'Settler' were among the least attractive (Table 3).

Separate groups of early, mid- and late season cultivars were compared for shelf life characteristics in 1992 (Table 4). Of the early season cultivars, 'Lester' rated among the highest in appearance before and after storage, and developed less mold during storage than other cultivars. 'Earliglow' rated among the lowest in appearance before and after storage. Of the mid-

Table 5. Evaluation of whole frozen then thawed strawberries from Benton Harbor, MI, 1991.

Cultivar	Appearance[1]	% Juice
Early season		
Annapolis	1.6	50
Cornwallis	3.0	47
Earliglow	3.1	42
Honeoye	2.3	46
Lester	4.7	34
Redcoat	4.0	35
LSD (0.05)	1.1	n.s.
Mid-season		
Glooscap	2.9	52
Gov. Simcoe	5.5	43
Selkirk	7.0	34
LSD (0.05)	2.0	7
Late season		
Allstar	7.0	--
Blomidon	5.5	38
Jewel	5.5	48
Kent	3.1	54
Midway	3.8	46
Settler	1.8	54
LSD (0.05)	1.8	7

[1]Appearance rated on a scale of 1 (very unattractive) to 10 (extremely attractive).

Table 6. Evaluation of whole frozen then thawed strawberries from Benton Harbor, MI, 1992.

Variety	Appearance rating	Over-all flavor rating	% Juice
	Early season		
Annapolis	2.1	6.0	43.8
Cornwallis	3.5	3.9	41.3
Earliglow	2.9	5.0	39.5
Honeoye	4.0	7.4	39.5
Lester	6.1	5.8	34.5
LSD (0.05)	1.6	2.5	5.2
	Mid-season		
Glooscap	1.9	5.4	43.3
Gov. Simcoe	4.3	6.0	35.8
Midway	3.2	6.6	40.5
Redcoat	4.7	8.1	36.3
Selkirk	5.1	4.8	25.8
LSD (0.05)	1.6	1.6	7.5
	Late season		
Allstar	5.6	4.1	33.0
Blomidon	4.7	5.2	32.3
Jewel	6.1	6.2	28.5
Kent	3.6	5.4	41.3
Lateglow	5.3	5.1	33.5
Settler	3.1	5.9	44.3
LSD (0.05)	1.7	1.4	8.3

[1]Appearance rated on a scale of 1 (very unattractive) to 10 (extremely attractive).

season cultivars, 'Governor Simcoe' and 'Selkirk' were among the most attractive before and after storage whereas 'Glooscap' and 'Midway' ranked lower in appearance than, other cultivars. 'Selkirk' also developed less mold during storage than other mid-season cultivars. 'Blomidon,' 'Allstar' and 'Jewel' rated highest of the late season cultivars in appearance after storage. Moisture loss during storage in 1991 and 1992 ranged from 4-8 % by weight, and did not vary consistently between cultivars (data not presented).

Cultivars also varied in firmness during 1991 (Table 3). 'Lester,' 'Redcoat' and 'Annapolis' rated highest in firmness of the early season cultivars, whereas 'Allstar,' 'Jewel' and 'Blomidon' were highest of the mid- to late season cultivars. Although these measurements were made with a prototype instrument and only during one season, cultivar differences were generally consistent with our observations in the field.

The suitability of cultivars for freezing was assessed by comparing their appearance and juice leakage after thawing in 1991 (Table 5) and 1992 (Table 6). Cultivars that rated highest in appearance were generally those that leaked the least juice while thawing. 'Lester' was among the most attractive early cultivars and generally leaked relatively little juice. Of the mid-season cultivars, 'Governor Simcoe' and 'Selkirk' rated high in appearance, whereas 'Glooscap' rated lowest. 'Allstar,' 'Blomidon' and 'Jewel' rated highest in appearance among the late cultivars.

The flavor of thawed berries was also tested by rating sweetness, sour-

Table 7. Summary of over-all cultivar attributes.[1]

Cultivar	Yield	Berry size	Shelf-life	Freezing quality
	Early season			
Annapolis	3	3	3	1
Cornwallis	3	1	2	2
Earliglow	1	1	2	2
Honeoye	3	2	2	2
Lester	3	2	3	3
Redcoat	2	1	2	2
Veestar	2	1	--[2]	--
	Mid-season			
Glooscap	3	2	1	1
Gov. Simcoe	2	2	3	2
Midway	2	1	1	2
Selkirk	3	2	3	3
Settler	3	3	1	1
	Late season			
Allstar	3	3	3	3
Blomidon	2	3	3	2
Jewell	3	3	2	3
Kent	3	3	1	1
Lateglow	2	3	2	2
Scotland	3	3	--	--

[1]Numerical ratings on a scale of 1 (lowest) to 3 (highest).
[2]Data not sufficient to rank.

ness, strawberry-like flavor, flavor intensity and off-flavors (1991) and simply overall flavor (1992). Cultivars seldom differed significantly in the flavor attributes rated in 1991 (data not presented), but taste panelists seemed to perceive these characteristics differently. Taste evaluations were simplified in 1992 by rating only over-all flavor. The over-all flavor of 'Cornwallis,' 'Selkirk' and 'Allstar' was rated lower than other cultivars (Table 6). However, similar tests over more years are needed to form clear conclusions. It should also be noted that these samples were frozen as whole, intact berries. Consumers often crush berries before freezing, which may affect flavor differently.

The general attributes of all cultivars are summarized in Table 7. The most productive cultivars in this trial were 'Honeoye' and 'Annapolis' (early season), 'Glooscap' (mid-season), and 'Allstar' and 'Kent' (late season). 'Lester,' 'Governor Simcoe' and 'Allstar' rated highest in shelf-life comparisons. 'Lester,' 'Governor Simcoe,' 'Selkirk,' 'Allstar' and 'Jewel' appeared most suited for freezing as whole berries.

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The Wilder Medal Committee of the American Pomological Society (APS) invites nominations for the 1994 Wilder Silver Medal Award. All active members of APS are eligible to submit nominations. The award was established in 1873 in honor of Marshall P. Wilder, the founder and first President of the society. The award consists of a beautifully engraved medal which is presented to the recipient at the annual meeting of APS, held during the ASHS Annual Meeting.

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Significant contributions to the science and practice of pomology other than fruit breeding will also be considered. Such contributions may relate to any important area of fruit production, such as rootstock development and evaluation, anatomical and morphological studies, or unusually noteworthy publications in any of the above subject areas.

Specific nomination guidelines, can be obtained by contacting committee chairperson, Dennis J. Werner, Department of Horticultural Science, Box 7609, North Carolina State University, Raleigh, NC 27695-7609 (phone 919-515-3166). Please submit your nominations by May 1, 1994.

Thank you.