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Production, Postharvest, and Freeze-Drying Evaluations of

Fresh-Cut Peonies

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1995 PRODUCTION, POSTHARVEST, AND FREEZE-DRYING EVALUATION OF FRESH-CUT PEONIES

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In the fall of 1992, a cultivar trial of peony plants *(Paeonia lactzflora) was* established at the Kansas State University Horticulture Research Center, Manhattan, KS, to determine which cultivars would provide good fresh-cut flowers. Since then, new cultivars have been added yearly, so the planting now includes 82 different cultivars (Table 1). The trial plots include at least five plants set 0.91 m apart within the beds. Beds are 0.91 m-wide with 1.22 m-wide grass aisles between beds. Besides yield and harvest date data, flowers from these trials were used for postharvest evaluations and freeze-drying studies.

Table 1. Peony cultivars included in planting at Horticulture Research Center--Manhattan, KS.

Cultivar	*Description*
RED	
Apache	Single, dark red, early mid-season
Cherry Bomb	Bomb, deep red, early mid-season
Comanche	Japanese, dark rose wine, early mid-season
David Harum	Double, light crimson, mid-season
Felix Crouse	Double, brilliant ruby red, mid-season
Felix Supreme	Double, rich ruby red, mid-season
Grover Cleveland	Double, deep crimson, late season
Harry Richardson	Double, rich carmine red, very late season
Henry Bocktoce	Double, true red, early mid-season
Judy Becker	Double, rich dark red, late mid-season
Kansas	Double, bright red, early season
Karl Rosenfield	Double, brilliant crimson, mid-season
Lora Dexheimer	Double, bright crimson, mid-season
Louis van Houtte	Double, dark red, late mid-season
Monsieur Martin Cahuzac	Double, very dark red, early mid-season
Montezuma	Single, crimson early season
Peter Brand	Double, very dark red, early mid-season
Philippe Rivoire	Bomb, very dark crimson, mid-season

Table 1. Peony cultivars included in planting at Horticulture Research Center--Manhattan, KS (cont'd).

Cultivar	*Description*
Raspberry Ice	Bomb, raspberry red/silver, early season
Red Charm	Bomb, double, dark red, early mid-season
Richard Carvel	Double, bright crimson, early season
Shawnee Chief	Double, dark red, mid-season
WHITE	
Bridal Shower	Bomb, pure white, mid-season
Bridal Icing	Bomb, pure white, mid-season
Capital Dome	Bomb, pure white, mid-season
Cloud Cap	Double, pure white, mid-season
DH1460	Double, pure white
Dr. F.G. Brethour	Double, creamy center, late-season
Duchess de Nemours	Double, light yellow center, early season
Elsa Sass	Double, pinkish cast, late season
Festiva Supreme	Double, crimson flecks, mid-season
Festiva Maxima	Double, crimson flecks, early season
Henry Sass	Double, pure white, late mid-season
Leading Lady	Double, pure white, late season
Lullaby	Double, blush to white, late season
Madame de Vernville	Bomb, blush center, early season
Snow Mountain	Bomb, pure white, late season
Spellbinder	Single, pure white, mid-season
69A	Bomb, ivory white, early season
PINK	
Armistice	Double, rose pink, late mid-season
Baroness Schroeder	Double, very light pink/blush, late mid-season
Better Times	Double, deep rose pink, late mid-season
Doris Cooper	Double, light pink, late season
Edulis Superba	Double, old rose pink, early season
Grace Batson	Double, medium pink, late mid-season
Hermoine	Double, light pink, late mid-season
James Pillow	Double, light pink, late season
Jayhawker	Bomb, soft pink, early season

Table 1. Peony cultivars included in planting at Horticulture Research Center--Manhattan, KS (cont'd).

Cultivar	*Description*
Lady Kate	Double, sparkling pink, very late season
Mister Ed	Bomb, soft pink, early season
Monsieur Jules Elie	Bomb, medium pink, early mid-season
Mrs. Franklin D. Roosevelt	Double, soft rose pink, mid-season
Ozark Beauty	Double, radiant pink, late season
Raspberry Sundae	Double, light creamy pink, mid-season
Reine Hortense	Double, light pink, crimson flecks, mid-season
Romance	Japanese, dark pink with yellow center, mid-season
Rose Pearl	Double, medium pink, mid-late season
Sarah Bernhardt	Double, apple blossom pink, late season
Solange	Double, buff with salmon pink center, late season
Souvenir de Louis Bigot	Double, rose pink/shell pink, mid-season
Therese	Double, old rose pink, mid-season
Walter Faxon	Double, shell pink, mid-season
Westerner	Japanese, soil pink, mid-season
Wrinkles 'n' Crinkles	Double, deep rose pink, late mid-season
CORAL	
Coral Fay	Single, hot rose coral, early season
Coral 'n' Gold	Single, orange coral, early season
Lovely Rose	Single, coral pink, very early season
Mrs. Livingston Farand	Double, coral pink, late season
Orange Lace	Japanese, pink with orange center, mid-season
BICOLOR	
Candy Heart	Double, white with red stripes, mid-late season
Lois Kelsey	Semi-double, white with red stripes, mid-season
Lord Cavin	Double, creamy pink with red stripes, mid-season

In 1993, a commercial size trial also was established of the cultivar 'Shawnee Chief, a red double. The initial planting included three beds 0.91 m-wide with 1.22 m-wide grass aisles between beds. Plants were set in double rows in the beds with 0.61 m between the double rows and 0.91 m between plants in the rows. Beds were 32 m long with a total of 70 plants per bed. In the fall of 1995, seven more beds were established in the same fashion. Four of these beds contain 'Shawnee Chief, and three of them contain 'Snow Mountain', a white bomb-type. Flowers from the initial beds were used for controlled- atmosphere storage studies.

Yield and Harvest Period Evaluation

Because only a minimal harvest can be taken in the third year, fill production usually does not occur until the fifth year. Yield data are given only for those cultivars in their third year (Table 2). Harvest periods are included for all cultivars that bloomed in 1995.

The spring of 1995 was cold, wet, and late. A couple of freezes killed flower buds of early cultivars. Single types bloomed much earlier than the doubles and bombs. Most cultivars bloomed too late for Memorial Day, the major market for peony flowers in Kansas.

Table 2.1995 Peony harvest period and yield at Horticulture Research Center -- Manhattan, KS.

Color	*Cultivars*	*Year Planted*	*Harvest Period*	*Yield**
RED	Apache	1993	26 May	-----
	Cherry Bomb	1993	30 May-3 June	-----
	Comanche	1993	31 May-7 June	-----
	David Harum	1992	28 May-4 June	8.0
	Felix Crouse	1992	30 May-12 June	10.6
	Felix Supreme	1992	29 May-3 June	8.8
	Grover Cleveland	1993	22 May-2 June	-----
RED	Henry Bocktoce	1994	26 May-1 June	-----
	Judy Becker	1992	30 May-3 June	3.0
	Kansas	1992	28 May-3 June	3.6
	Karl Rosenfield	1992	22 May-4 June	8.8
	Lora Dexheimer	1992	22 May-2 June	4.4
	Louis van Houtee	1993	30 May-5 June	-----
	Mon. Martin Cahuzac	1992	28 May-6 June	6.5
	Philippe Rivoire	1992	30 May-12 June	5.8
	Red Charm	1993	30 May	-----
	Richard Carvel	1992	22 May-7 June	-----
	Shawnee Chief	1992	1-7 June	9.0
PINK	Baroness Schroeder	1992	1-12 June	1.8
	Better Times	1993	28 May-2 June	-----
	Coral Fay	1994	9-11 May	----
	Coral n' Gold	1994	22 May	----
	Doris Cooper/Lady Kate	1992	3-8 June	----
	Edulis Superba	1992	25 May-2 June	7.6

Table 2. 1995 Peony harvest period and yield at Horticulture Research Center -- Manhattan, KS (cont'd).

Color	Cultivars	Year Planted	Harvest Period	Yield*
	Grace Batson	1992	1-3 June	4.8
	Hermoine	1993	2 June	----
	James Pillow	1992	2-7 June	6.8
	Jayhawker	1993	29 May	----
	Lovely Rose	1993	16-22 May	----
	Mister Ed.	1992	26 May-7 June	5.6
	Mon. Jules Elie	1992	22 May-3 June	3.8
PINK	Mrs. F. D. Roosevelt	1992	20 May-5 June	7.6
	Orange Lace	1994	15-19 May	----
	Ozark Beauty	1993	2-8 June	----
	Raspberry Sundae	1992	28 May-7 June	6.8
	Reine Hortense	1992	28 May-6 June	3.0
	Sarah Bernhardt	1992	3-5 June	2.5
	Souvenir de Louis Bigot	1992	30 May-4 June	2.0
	Therese	1992	3-8 June	9.0
	Walter Faxon	1992	2-12 June	8.0
	Westerner	1993	1-5 June	----
	Wrinkles n' Crinkles	1993	2-12 June	----
WHITE	Bridal Icing	1994	26 May-4 June	----
	Bridal Shower	1994	25-29 May	----
	Capitol Dome	1993	26 May	----
	Dr. F.G. Brethour	1992	30 May-8 June	3.6
	Elsa Sass	1993	7-12 June	----
	Festiva Supreme	1992	26 May-3 June	7.2
	Festiva Maxima	1992	26 May-8 June	7.4
WHITE	Henry Sass	1992	2-7 June	6.2
	Lois Kelsey	1992	22 May-1 June	3.4
	Lullaby	1994	12 June	----
	Mme. de Vemville	1994	19 May	----

* No yield data are listed for cultivars less than 3 years old.

Harvest and Handling for Postharvest Evaluations

Peony flowers were harvested when they were at the colored, soft bud stage and later up to fully open. Harvests were done at least once a day and sometimes twice a day to harvest flowers at minimum maturity. In warm weather, harvesting flowers at minimum maturity was often difficult because flower opening is temperature dependent. Stems were cut at least 45 cm, bunched with rubber bands by cultivar, and labeled. Flowers then were transported to the laboratory for sorting and grading for the various postharvest studies, which included initial vaselife, vaselife after various periods of cold storage, freeze drying, and controlled-atmosphere storage.

For all evaluations, leaves on the bottom 2/3 of the stem were removed. Stems were recut under water to 30 cm. Five stems then were placed in labeled 0.8-liter glass jars with 0.6 liters of municipal tap water. Water was added as needed to maintain the initial level. Vaselife was evaluated after the flowers opened. Vaselife was considered over when the petals dropped or were wilted. Flowers were held under simulated consumer conditions, 20° C and light levels of 15.1 µmol/sec/m^2.

For initial vaselife studies, flowers were set up for evaluation within 24 hours of harvest. If flowers were not handled immediately, they were placed in cold storage at 4° C for no more than 24 hours.

For extended storage and controlled-atmosphere studies, the sorting and grading process included bunching the flowers by fives with rubber bands, labeling the bunches with cultivar name and date, and placing the bunches in 2-gallon plastic ziplock bags. The bagged flowers then were placed in cold storage at 1° C. Bunches were removed from storage at prescribed times for the different studies. Depending on the number of available flowers of each cultivar, extended cold storage lasted up to 6 weeks.

Controlled-Atmosphere Storage

'Shawnee Chief' flowers from the commercial block were used for the controlled-atmosphere storage studies. Control flowers stored under ambient atmosphere conditions were handled the same as extended-storage flowers. The controlled-atmosphere treatment flowers were sealed in 33-gallon plastic trash can chambers with Lexan™ lids in the same cold storage room where control flowers were placed. An atmosphere of 10% O_2± 2.0% and 8% $C0_2$± 2.0% was placed over the flowers in the sealed chambers. Storage period treatments were 4, 8, and 12 weeks under the controlled-atmosphere and for the controls. Each treatment had its own chamber, so as not to disrupt the continuity of the controlled atmosphere of longer treatments.

'Shawnee Chief' peony flowers stored under controlled-atmosphere conditions (10% O_2±2.0% and 8% CO_2± 2.%) had no better vaselife than the controls. Vaselife generally decreased with length of storage term (Table 3). However, flowers stored for 12 weeks lasted over a half day longer than those stored for 8 weeks. This may have been due to flower variability at harvest.

Table 3. Vaselife of 'Shawnee Chief' peony flowers initially and after 4, 8, and 12 weeks of cold storage with a controlled-atmosphere(CA) and without it (no CA).

Storage Term Treatment	*Vaselife* (days)*
Initial	7.7a
4 weeks - CA	5.5
- no CA	5.0b
8 weeks - CA	4.3
- no CA	4.0°
12 weeks - CA	4.7
- no CA	4.9b

*Different letters signify differences (p=0.05) in cold storage and not in controlled-atmosphere treatment. Means are based on three replications of five flowers.

Postharvest Life Evaluations of Fresh-Cut Peony Flowers

If 7 days is used as an acceptable vaselife for fresh-cut peonies, then of those evaluated immediately after harvest or with minimal storage (24 hours or less), all the white cultivars were acceptable and all but 'Kansas' of the red cultivars were acceptable (Table 4). Of the pink cultivars evaluated, several were deemed unacceptable. The unacceptable pink cultivars included two rather common cut flowers 'Sarah Bernhardt' and 'Edulis Superba'. The acceptable pink cultivars include a wide range of shades of pink and harvest seasons.

Storage for 1 week significantly decreased the vaselife of the pink cultivars 'James Pillow', 'Mrs. F.D. Roosevelt', 'Raspberry Sundae', and 'Therese'; the red cultivar 'Shawnee Chief'; and the white cultivar 'Festiva Supreme' (Table 5). Storage for 1 week had no effect on the rest of the cultivars evaluated.

After 2 weeks' storage, significant decreases in vaselife occurred for 'Edulis Superba', 'Felix Supreme', 'Festiva Maxima', and 'Shawnee Chief (Table 6). Vaselife increased for 'Sarah Bemhardt'.

Long-term storage of 5 weeks or more resulted in a progressively shorter vaselife for both 'Edulis Superba' and 'Festiva Maxima' (Table 7).

Table 4. Postharvest life of peony flowers immediately after harvest.

Cultivar	*Postharvest Life (days)**
PINK	
James Pillow	9.5 a
Mister Ed	8.5 b
Mrs. Franklin D. Roosevelt	8.3 bc
Raspberry Sundae	8.0 bcd
Grace Batson	7.8 cde
Walter Faxon	7.3 def
Therese	7.2 efg
Better Times	7.1 efg
Monsieur Jules Elie	6.4 gh
Edulis Superba	6.3 h
Reine Hortense	6.1 hi
Ozark Beauty	6.0 hi
Sarah Bernhardt	5.6 i
Wrinkle 'n' Crinkles	5.5 i
WHITE	
Festiva Supreme	8.6 a
Dr. F.G. Brethour	8.3 a
Henry Sass	8.1a
Lois Kelsey	7.4 b
Festiva Maxima	7.3 b
RED	
David Harum	9.0 a
Felix Supreme	8.5 a
Karl Rosenfield	7.7 b
Felix Crouse	7.7 b
Philippe Rivoire	7.6 bc
Shawnee Chief	6.9 cde
Richard Carvel	6.8 de
Monsieur Martin Cahuzac	6.6 e
Lora Dexheimer	6.5 e
Kansas	5.5 f

* Means, by flower color, followed by the same letter are not significantly different at 5% level.

Table 5. Comparison of postharvest life of peony flowers after harvest (0) and after 1 week of storage (1) at 2° C.

Cultivar	*Storage Time (weeks)*	*Postharvest Life (days)**
PINK		
Edulis Superba	0	6.3 defg
	1	5.5 fg
James Pillow	0	9.5 a
	1	7.7 bc
Mrs. Franklin D. Roosevelt	0	8.1b
	1	6.5 def
Raspberry Sundae	0	8.0 b
	1	5.3 g
Sarah Bernhardt	0	5.6 fg
	1	6.1 efg
Therese	0	7.2 bcde
	1	5.4 g
Walter Faxon	0	7.3 bcd
	1	6.8 cde
WHITE		
Festiva Maxima	0	7.3 b
	1	6.6 b
Festiva Supreme	0	8.6 a
	1	7.0 b
RED		
Felix Crouse	0	7.7 b
	1	6.9 bc
Felix Supreme	0	8.5 a
	1	8.0 ab
Richard Carvel	0	6.9 bc
	1	6.1 cd
Shawnee Chief	0	6.9 bc
	1	5.3 d

* Means, by flower color, followed by the same letter are not significantly different at 5% level.

Table 6. Comparison of postharvest life of peony flowers after harvest (0) and after 1 and 2 weeks of storage (1) at 2° C.

Cultivar	*Storage Time (weeks)*	*Postharvest Life (days)*
PINK		
Edulis Superba	0	6.3 def
	1	5.5 fghi
	2	4.9 ij
Sarah Bernhardt	0	5.6 fgh
	1	6.1 efg
	2	6.9 cde
WHITE		
Festiva Maxima	0	7.3 bc
	1	6.6 def
	2	4.5 j
RED		
Felix Supreme	0	8.5 a
	1	8.0 ab
	2	7.1 cd
Richard Carvel	0	5.5 fghi
	1	6.1 efg
	2	6.1 efg
Shawnee Chief	0	6.9 cde
	1	5.3 ghij
Shawnee Chief	2	5.3 ghij

* Means, by flower color, followed by the same letter are not significantly different at 5% level.

Table 7. Long-term storage results for 'Edulis Superba' and Festiva 'Maxima' fresh-cut peony flowers at 2° C.

	Cultivar	
Storage Time (weeks)	***'Edulis Superba '***	***'Festiva Maxima'***
0	6.3 a[Z]	7.3a[Z]
1	5.5 b	6.6 a
2	4.9 c	4.5 b
3	5.1 bc	5.1 b
4	4.7 c	4.3 c
5	3.9 d	2.4 C
6	----	1.5d

* Means followed by the same letter are not significantly different at 5% level.

Freeze-Dried Flower Evaluations

Thirty cultivars of herbaceous peony from the Kansas State University Horticulture Research Center--Manhattan, KS were harvested in the colored bud stage in spring, 1995. The harvested flowers then were allowed to open under ambient temperatures (18-24° C) in water to a half-open stage where the calyx was reflexed and petals were unfurling but not reflexing downward. Stems were cut to 15 cm, and then the flowers were freeze dried in a Vitris Model 36X66 Freeze Dryer (The Virtis Company, Gardiner, NY) for 8 days. The freeze/drying cycle was programmed with an initial 24-hour freezing cycle at -35° C, after which a vacuum was applied to 30-50 microns Hg and the temperature was raised incrementally to 20° C over the next 7 days. Flowers then were removed from the vacuum chamber, and moisture content was allowed to equilibrate with the air. Percent moisture of the stems and flowers then was measured by redrying a representative sample of the flowers and stems in a drying oven at 60° C for 24 hours.

Flower strength was measured by adapting techniques developed by Chen (Kansas State University M.S. Thesis, 1995). The stem was removed, and the flower was placed with the stem end down and the petals up on a wooden platform on an Instron Universal Testing Machine, Model 4502 (Instron Co., Canton, MA), A 120x5 mm stainless steel disk was used for a compression test. A 1 kilo-newton load cell, a speed of 300 mm/min, and sampling rate of 5 points/see were used for the test. An IBM-compatible 486 computer integrated the Instron readings. The force to crush the flowers is expressed in Mpa.

Stem strength also was measured by adapting techniques developed by Chen (Kansas State University M.S. Thesis, 1995). After the stems were removed from the flowers, they were trimmed to 7 cm. Individual stems then were placed in a wooden support platform to hold them while they were sheared with a razor blade attached to an Instron Universal Testing Machine, Model 4502. A 1 kilo-newton load-cell, a speed of 25 mm/min, and sampling rate of 5 points/sec

were used for the test. An IBM-compatible 486 computer integrated the Instron readings, The force to shear the stems is expressed in Mpa.

Six replications of each cultivar were used for each strength evaluation. Statistically, the experiment was a completely randomized design. Data were analyzed by SAS--PROC GLM with least square means separation.

Pink Peonies

Differences in flower strength occurred among the cultivars (Table 8). 'James Pillow' was stronger than most other cultivars. 'Grace Batson' stems were stronger than those of all other cultivars except 'James Pillow'. Therefore, 'James Pillow' appears to be the best choice overall. Because no industry standards are set for flower and stem strength of freeze-dried flowers, lack of differences among the majority of the cultivars gives the grower and freeze drier a wide choice of shades of pink peonies to freeze dry.

White Peonies

No significant differences in flower strength occurred among the three cultivars. However, stem strength did differ among the cultivars. 'Henry Sass' stems were stronger than 'Festive Maxima' stems.

Red Peonies

Differences were seen among the cultivars. 'Shawnee Chief' appears to be the best performer, because both stem and flower strengths were significantly greater than those of most other cultivars. 'Felix Crouse', a very common cultivar, and 'Philippe Rivoire' and 'Cherry Bomb', very dark red cultivars, proved to be very fragile and are unsuitable candidates for freeze drying. The very dark red cultivars changed color to an unacceptable black red.

Table 8. Flower and stem strength of freeze-dried peony cultivars.

Cultivar	*Flower Strength (Mpa)*	*Stem Strength (Mpa)*
PINK		
Edulis Superba	1.26 ab[z]	1.09 bc
Grace Batson	0.59 b	1.62 a
James Pillow	2.72 a	1.38 ab
Mister Ed	1.46 ab	0.96 be
Mrs. F.D. Roosevelt	1.06 b	l.10 bc
Mon. Julies Elie	0.79 b	0.80 be
Ozark Beauty	1.42 ab	0.54 c
Reine Hortense	0.71 b	0.78 C

Table 8. Flower and stem strength of freeze-dried peony cultivars (cont'd).

Cultivar	*Flower Strength (Mpa)*	*Stem Strength (Mpa)*
Raspberry Sundae	0.91 b	l.10 bc
Sarah Bemhardt	0.96 b	1.08 bc
Souvenir Louis de Bigot	0.36 b	0.60 **C**
Therese	0.72 b	0.73 c
Walter Faxon	0.77 b	0.97 bc
WHITE		
Dr. F. G. Brethour	1.24 a	1.29 ab
Festiva Maxima	1.55 a	0.93 b
Henry Sass	1.61 a	1.65 a
RED		
Cherry Bomb	0.57 e	0.86 c
David Harum	3.05 ab	1.27 bc
Felix Crouse	1.14d	1.01 bc
Felix Supreme	1.84 cd	
Judy Becker	1.18d	1.47 ab
Kansas	3.51 ab	1.16b
Lora Dexheimer	2.08 bcd	1.60 a
Mon. Martin Cahuzac	2.72 abc	1.30 bc
Philippe Rivoire	0.98 de	1.02 bc
Shawnee Chief	4.02 a	1.39 ab

[z]Means, by flower color, followed by the same letter are not significantly different at 5% level.

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