'Diva' Apple

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'Diva' is the first scab-resistant apple released, specifically for northern climates, for cider and ice cider production and fresh market. It is very winter-hardy (lowest temperature –20 to –35 °C, Zones 4 to 5), has an excellent shelf life compared with 'Macspur McIntosh', and produces high-quality cider.

'Macspur McIntosh' was used for comparison, in this study, as a result of its use for processing similar to the 'McIntosh' in Quebec.

'Diva', tested as SJC7123-1, originated from a cross made in 1971 between 'McIntosh' and 9AR5T17 (test code PRI 674) (Fig. 1) at Agriculture and Agri-Food Canada (AAFC). The seedling (14179) has been tested since 1974 at AAFC and examined for its hardiness, disease resistance, fruit quality, chemical composition, and shelf life after storage at 2 °C. After extensive testing, it was planted in replicated trials under the name SJC7123-1 at four locations, including Cidrerie du Minot, a commercial cider producer in Hemmingford (lat. 45.05° N, long. 73.60° N), Quebec.

Flower and Fruit Characteristics

Flowering starts at the same time as 'Macspur McIntosh' and 1 d ahead of 'Spartan' in L'Acadie, AAFC Experimental Farm

(lat. 45.32° N, long. 73.35° W). Flowers are single and their average size is 5.4 cm. In full balloon stage, flower buds are covered with a blush of vivid reddish purple [Horticultural Society Color Chart (RHS) RHS 58A] (RHS, 1995) that gradually becomes solid. When fully opened, petals are mainly ovate, slightly overlapped, and mainly white with various patterns of medium to dark pink (RHS 58A) on the lower side, whereas the pattern is blush on the upper side. The pedicels are mainly green but can sometimes have a red stripe.

Fruit ripe late, during the second week of October, in Frelighsburg, Quebec (lat. 45° N, long. 72° W) ≈3 weeks after 'McIntosh' and 1 week after 'Cortland'. Fruits are medium size and have a transverse diameter between 6.4 and 7.6 cm (Fig. 2) and an average weight of 166 g at harvest. Fruit shape can be round-conic to somewhat oblong. The sides of the fruit are sometimes slightly ribbed along the body and can be a bit lopsided (Fig. 3). Skin is smooth, not waxy and thick. Overcolor of

skin is dark red (RHS184A to RHS185A), flushed in some areas, but also has stripes and streaks in other areas, whereas ground color is yellowish green (RHS154D). Surface bloom is almost absent. Lenticels are small to medium size, only slightly conspicuous on the ground color and on striped areas, whereas they are somewhat prominent on areas where the overcolor is flushed. Stem length is equal to or longer than the shoulders. Cavity is acute, fairly narrow and shallow with a low to medium amount of russetting. Basin can be slightly wavy to intermediately crowned, fairly shallow, and its width is medium to somewhat broad. Calyx is persistent, lobes are free at the base, and calyx is opened and medium to large. Seeds are brown and globose-conic. At harvest, the flesh is cream, crispy, juicy, and firm (6.4 to 7.3) with a very high discoloration depending on time after cutting, core line is not distinct, and locules are opened. Flavor is pleasant, sweet, and slightly tart. Titratable acidity (TA) is 0.69% (malic acid), pH is 3.41, and soluble solids content (SSC) is between 12% and 13% (Brix).

Phenolic Composition

The phenolic composition of flesh and peel of 'Diva' was evaluated and compared with 'Macspur McIntosh' using methods and procedures as described previously (Tsao et al., 2005, 2006) using high-performance liquid chromatography. In the peel of both genotypes, the phenolic composition was similar except for *p*-coumaroylquinic acid, which was significantly lower in 'Diva' (Table 1). In the flesh, 'Diva' had a lower *p*-coumaroylquinic acid content as well as a lower level of procyanidin, especially procyanidin B1 (Table 2). The levels of these phenolics might affect the final cider quality as explained previously (Khanizadeh et al., 2007, 2008) and is worth further investigation along with their effect on disease susceptibility (Ehsani-Moghaddam et al., 2008; Tao et al., 2008).

Storage and Other Horticultural Characteristics

After 2.5 months of regular cold storage at 2 °C, fruit quality, taste, and firmness were

Fig. 1. Pedigree of 'Diva' apple.

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Fig. 2. Fruit of 'Diva' (left) and 'Macspur McIntosh' (right) apple.

Fig. 3. Fruit of 'Diva' at maturity.

good. After 4.5 months in regular cold storage, fruit was firm (6.2 to 6.4) as measured by a EPT-1 Pressure Tester (Lake City Technical Products Inc., Kelowna, BC, Canada), TA was less than average (0.43%), and SSC was medium (12%). Its fresh eating qualities are excellent and taste and aroma are good. Fruit quality is superior in texture and taste compared with 'Spartan' stored under similar conditions.

SJC7123-1 is presently being evaluated at several research centers in Europe by Meiosis Inc. (Bradbourne House, Kent, UK) and by other AAFC Research Centers, including New Brunswick, Bouctouche (lat. 46.46° N, long. 64.73° W), Nova Scotia, Kentville (lat. 45.06° N, long. 64.50° W), Nova Scotia Agricultural College, Nova Scotia (lat. 45.06° N, long. 64.50° W), and also by the Ontario Ministry of Agriculture, Food and Rural Affairs, Simcoe, Ontario (lat. 43.55° N, long. 80.25° W) in comparison with other known local cultivars.

Diseases

'Diva' is resistant to apple scab [*Venturia inaequalis* (Cke) Wint.] and no sign of fire blight, caused by *Erwinia amylovora* (Burril) Winslow et al., was observed during the evaluation period.

Field Performance

Four trees of each cultivar ('Diva' and 'Macspur McIntosh') were planted 2.0 m apart within the row and 4.5 m spacing between the rows using 'M26' rootstock at four locations [L'Acadie, Frelighsburg, Dunham, and Mont St-Grégoire (lat. 45.05° N, long. 73.60° W)]. Over five harvests (2003 to 2007 inclusive), 'Diva' was more precocious with higher cumulative yield compared with 'Macspur McIntosh' (Table 3). There was no significant difference between the fruit size of 'Diva' and 'Macspur McIntosh'. 'Diva' tested since 1974 and survived the test winter of 1980–1981, 1986–1987, and 1993–1994 (Granger, 1981; Granger et al., 1991) and no significant preharvest drop was observed during the evaluation period.

Fermentation and Cider Evaluation

'Diva' was compared with several genotypes used for cider production by 'Cidrierie du Minot', a commercial cider producer (<http://www.duminot.com>) using its standard routine to make cider as follows. The apples were picked at maturity and stored between 1 and 2 °C for 1 to 2 months until pressing. Each genotype was grounded and pressed separately using a standard cider press. Eighteen liters of must were collected from each genotype and transferred into separate carboys where yeast (*Saccharomyces cerevisiae* Meyen ex E.C. Hansen) was added and fermentation proceeded at 12 °C. During the fermentation process, SSC (Brix) and TA readings were carried out twice a week. Bentonite was added to stabilize and clarify

Table 1. Phenolic composition ($\mu\text{g}\cdot\text{g}^{-1}$ fresh–frozen weight) in the peel of ‘Diva’ and ‘Macspur McIntosh’.

Phenolic composition	Macspur McIntosh ^z	Diva ^z	Least significant difference
Chlorogenic acid	85.8	95.3	23.7
Neochlorogenic acid	16.6	22.2	6.6
<i>p</i> -Coumaroylquinic acid	38.1	4.7	7.3
Other hydroxycinnamic acids	27.8	50.2	8.3
Total hydroxycinnamic acids	168.3	172.4	—
Catechin	26.0	42.4	20.5
Epicatechin	130.4	116.1	66.5
Procyanidin B1	32.0	24.0	98.9
Procyanidin B2	92.6	70.4	41.6
Other procyanidins	57.4	37.8	28.6
Total procyanidins	338.4	290.7	—
Cyanidin-3-galactoside	51.3	63.9	75.9
Cyanidin-3 galactoside equivalent	4.2	0.0	10.6
Total cyanidins	55.5	63.9	—
Quercetin-3-galactoside	84.9	98.1	50.2
Quercetin-3-xyloside	75.5	32.3	16.3
Quercetin-3-arabinoside	40.3	28.9	17.6
Quercetin-3-rhamnoside	91.3	56.9	30.6
Other flavonols	113.3	134.4	59.6
Total flavonols	405.3	350.6	—
Phloridzin	43.3	40.8	42.8
Phloretin derivative	31.0	39.7	15.6
Total dihydrochalcones	74.3	80.5	—

^zData are the average of duplicates.Table 2. Phenolic composition ($\mu\text{g}\cdot\text{g}^{-1}$ fresh–frozen weight) in the flesh of ‘Diva’ and ‘Macspur McIntosh’.

Phenolic composition	Macspur McIntosh ^z	Diva ^z	Least significant difference
Chlorogenic acid	165.9	170.3	34.1
Neochlorogenic acid	10.3	21.8	15.0
<i>p</i> -Coumaroylquinic acid	57.0	7.9	14.4
Total hydroxycinnamic acids	233.2	200.0	—
Catechin	32.2	28.1	28.4
Epicatechin	50.5	45.5	36.3
Procyanidin B1	17.6	0.0	18.0
Procyanidin B2	64.7	65.1	25.6
Other procyanidins	20.7	7.7	14.3
Total procyanidins	185.7	146.4	—
Quercetin-3-rhamnoside	4.6	4.4	1.6
Total flavonols	4.5	4.4	—
Phloridzin	7.3	6.2	4.1
Phloretin-3-xyloglucoside	16.7	11.2	4.1
Total dihydrochalcones	24.0	17.4	—

^zData are the average of duplicates.

Table 3. Yield, average fruit weight, and cumulative yield of ‘Diva’ and ‘Macspur McIntosh’.

Genotype	Yield (kg) ^z						Avg fruit wt ^z (g)
	2003	2004	2005	2006	2007	Cumulative	
Macspur McIntosh	2.7	12.6	9.7	10.3	17.8	53.1	167.4
Diva	6.5	15.7	9.7	17.6	16.9	66.4	150.0
Least significant difference (0.05)	2.5	6.6	3.4	2	4.8	—	4.6

^zData are the average of trees grafted on M26 and planted in a completely randomized design using four replicates in L’Acadie, Quebec.

proteins and, once the desired alcohol and remaining sugar content had been achieved, the fermentation was halted by reducing the temperature and clarified using 0.45- μm filters. Alcohol, density, and TA were measured

and sulfur dioxide was added for sterilization. Finally, the cider was carbonated and bottled. The final cider was evaluated by four experienced judges similar to the ones involved in the previous work (Khanizadeh et al., 2000)

and ‘Diva’ ranked higher than ‘Macspur McIntosh’ for all attributes, visual, olfactory, and taste (Table 4). ‘Macspur McIntosh’ was used in this study for comparison as a result of its wide use for processing, similar to ‘McIntosh’ in Quebec.

Availability

A Canadian Plant Breeder’s Right has been issued (Application No. 06-5437, <http://www.inspection.gc.ca/english/plaveg/pbrpov/cropeport/app/app00006302e.shtml>) and limited quantities of nonindexed budwoods are available for research purposes (universities and research stations) from Shah-rokh Khanizadeh (North America) or from Mieosis Inc. (Europe) on written request. Interested nurseries may enquire about “non-exclusive licenses” directly from AAFC.

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Table 4. Sensory characteristics of ‘Diva’ and ‘Macspur McIntosh’ cider.

Sensory characteristics	Diva	Macspur McIntosh ^z
Visual attributes	Brilliant, straw yellow, slightly darker than Macspur McIntosh	Brilliant, pale yellow
Olfactory attributes	Strong intensity, lots of fruit (citrus), interesting, delicate	Weak intensity, green fruit, somewhat earthy, delicate
Taste attributes	Fruity (citrus), well-balanced, freshness, very interesting in whole	Short, slightly astringent finish that is not unpleasant, well-balanced
Overall score/100	80.7	77.3

^zMacspur McIntosh^z was used in this study for comparison due to its use for processing, similar to the ‘McIntosh’ in Quebec.