‘Diva’ Apple

Shahrokh Khanizadeh1 and Yvon Groleau

Agriculture and Agri-Food Canada, Fruit Breeding and Physiology Laboratory, Horticultural Research and Development Centres, 430 Gouin Boulevard, St-Jean-sur-Richelieu, Quebec J3B 3E6, Canada

Rong Tsao and Raymond Yang

Agriculture and Agri-Food Canada, Guelph Food Research Centre, 93 Stone Road West, Guelph, Ontario N1G 5C9, Canada

Inteaz Alli

Faculty of Agricultural and Environmental Sciences, Department of Food Science, Macdonald Campus of McGill University, 21,111, Lakeshore Road, Ste Anne de Bellevue, Quebec, H9X 3V9, Canada

Robert Prange

Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 32 Main Street, Kentville, Nova Scotia, B4N 1J5, Canada

Robert Demoy

Cidrerie du Minot, 376 chemin Covey Hill, Hemmingford, Quebec, Canada J0L 1H0

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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 ‘Maccspur McIntosh’, and produces high-quality cider. ‘Maccspur 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 (AAFC). The seedling (14179) has been released, specifically for northern climates, for cider and ice cider production and fresh market. ‘Diva’ (Fig. 1) 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 ‘Maccspur 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 Freleighsburg, 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 ‘Maccspur 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...
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 ‘Cidrerie 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 ground 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 (μg g⁻¹ fresh–frozen weight) in the peel of ‘Diva’ and ‘Macspur McIntosh’.

| Phenolic composition                          | Macspur McIntosh* | Diva* | Least significant difference |
|-----------------------------------------------|-------------------|-------|-----------------------------|
| Chlorogenic acid                              | 165.9             | 170.3 | 34.1                        |
| Neochlorogenic acid                           | 10.3              | 21.8  | 15.0                        |
| p-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-galactoside                       | 4.6               | 4.4   | 1.6                         |
| Total flavonols                               | 4.5               | 4.4   | —                           |
| Phloridzin                                    | 7.3               | 6.2   | 4.1                         |
| Phloretin derivative                          | 16.7              | 11.2  | 4.1                         |
| Total dihydrochalcones                        | 24.0              | 17.4  | —                           |

*Data are the average of duplicates.

Table 2. Phenolic composition (μg g⁻¹ fresh-frozen weight) in the flesh of ‘Diva’ and ‘Macspur McIntosh’.

| Phenolic composition                          | Macspur McIntosh* | Diva* | Least significant difference |
|-----------------------------------------------|-------------------|-------|-----------------------------|
| Chlorogenic acid                              | 23.7              | 12.6  | 9.3                         |
| Neochlorogenic acid                           | 10.3              | 21.8  | 15.0                        |
| p-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-galactoside                       | 4.6               | 4.4   | 1.6                         |
| Total flavonols                               | 4.5               | 4.4   | —                           |
| Phloridzin                                    | 7.3               | 6.2   | 4.1                         |
| Phloretin derivative                          | 16.7              | 11.2  | 4.1                         |
| Total dihydrochalcones                        | 24.0              | 17.4  | —                           |

*Data are the average of duplicates.

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

| Genotype          | Yield (kg)*   | Avg fruit wt (g) | Cumulative 2003–2007 | Least significant difference (0.05) |
|-------------------|---------------|------------------|-----------------------|-----------------------------------|
| Macspur McIntosh  | 2.7           | 12.6             | 10.3                  | 17.8                              |
| Diva              | 6.5           | 15.7             | 9.7                   | 17.6                              |

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

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

| Sensory characteristics | Diva* | Macspur McIntosh* |
|------------------------|-------|-------------------|
| 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 astrin rent finish that is not unpleasant, well-balanced |

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

Literature Cited

Ehsani-Moghadam, B., M.T. Charles, O. Carisse, and S. Khanizadeh. 2008. Regulation of superoxide dismutase isoforms in resistant and susceptible strawberry cultivars subjected to leaf spot disease. Archives of Phytopathology and Plant Protection. 41:492–500.

Granger, R.L. 1981. Notes concerning the harsh winter of 1980/1981. Fruit Notes. 46:14–16.

Granger, R.L., G.L. Rousseau, M. Meheriuk, and A.H. Quamme. 1991. Promising winter hardy apple rootstock from a breeding program at Morden, Manitoba. Fruit Var. J. 45:185–186.

Khanizadeh, S., Y. Groveau, I. Ali, D. Guarino, and R. Dumois. 2000. New hardy apple scab resistant selections for cider and juice production. Acta Hort. 538:697–702.

Khanizadeh, S., R. Tsao, D. Rebaka, R. Yang, M.-T. Charles, and V. Rupasinghe. 2008. Polyphenol composition and total antioxidant capacity of selected apple genotypes for processing. Journal of Food Composition and Analysis. 21:396–401.

Khanizadeh, S., R. Tsao, D. Rebaka, R. Yang, and J. DeEll. 2007. Phenolic composition and antioxidant activity of selected apple genotypes. J. of Food. Afr. Environ. 5:61–66.

Royal Horticultural Society Colour Chart (RHS). 1995. Royal Horticultural Society, London, UK.

Tsao, T., S. Zhang, C. Beldica, R. Tsao, M.T. Charles, R. Yang, and S. Khanizadeh. 2008. In vitro antifungal activity and mode of action of selected antioxidants on Botrytis cinerea. Archive Phytopathol & Plant Protection (In press MS ID: 358551).

Tsao, R., S. Khanizadeh, and A. Dale. 2006. Designer fruits and vegetables with enriched phytochemicals for human health. Can. J. Plant Sci. 86:773–786.

Tsao, R., R. Yang, E. Sockowie, and S. Khanizadeh. 2008. Which polyphenolic compounds contribute to the total antioxidant activities of apple? J. Agr. Food Chem. 53:4989–4995.

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