

# Low-input Apple Production Systems Consumer Acceptance of Disease-resistant Cultivars

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**Abstract.** An untrained panel evaluated five apple cultivars [*Malus domestica* Borkh. cvs. Liberty, Prima, Priscilla, and Freedom (all scab resistant) and Spur Red Delicious (Bisbee strain)] in 1988 and 1989 to determine consumer acceptability and opinion of quality. Testers evaluated fruit for five quality characteristics (texture, juiciness, aroma, tartness, and sweetness) plus overall quality in a random, blind taste test on 30 Sept. 1988. Testers consistently identified 'Spur Red Delicious' (9% soluble solids content) as undesirable for all attributes. Tasters could not discern differences in juiciness among the cultivars. 'Freedom' was rated excellent, 'Liberty' and 'Prima' very good to good, and 'Priscilla' good in overall quality. In a separate blind, random preference test, 'Freedom', 'Liberty', and 'Prima' received higher preference ratings than 'Priscilla'. The taste tests were repeated using the same five cultivars on 3 Oct. 1989. 'Freedom' and 'Liberty' received the highest ratings for overall quality. Freedom received the highest preference ratings. Results, in general, were consistent from year to year. Since we tested only one strain of 'Red Delicious', we cannot conclude from this work that resistant cultivars are preferred to any standard; however, we can conclude that resistant cultivars are acceptable to the consumer.

Apples receive the highest amount of agricultural chemicals on a per-unit basis of any major food crop grown in the United States (Metcalf, 1980). Some commercial growers devote half of their pesticide use to disease management (Polk, 1989; unpublished data, 1990). New Jersey growers use an average of 112 kg of formulated pesticide/ha for disease and arthropod control, of which 22 kg are fungicides and 24 kg are insecticides (Polk, 1989; unpublished data, 1990). Based on area and recommended rates of N-[(trichloromethyl)thio]-4-cyclohexene-1,2-dicarboximide (captan), bis(dimethylthio-carbamoyl)disulfide (thiram), and ferric dimethyldithiocarbamate (ferbam), the elimination of just one fungicide application over Pennsylvania and New Jersey apples would reduce fungicide use by 84 t·year<sup>-1</sup> (formulated material). The integration of disease-resistant cultivars (DRCs) into commercial apple production offers a realistic approach for reducing pesticide use in fruit production.

As part of a U.S. Dept. of Agriculture project, Development of a Low-Input Apple Production System for the Northeast, we are evaluating the performance, management needs, and marketing requirements of several DRCs

for commercial production. Before DRC orchards are widely planted, we must determine whether or not the DRCs currently available are acceptable to most consumers. To make recommendations to growers, we need to know how consumers rank the quality of resistant cultivars. This taste test was performed to determine if: 1) an untrained panel could discern differences in apple quality, 2) the cultivars tested are acceptable to the consumer, and 3) any cultivar would be rated significantly better than another.

**Taste-testing protocol.** An untrained panel evaluated five apple cultivars ['Liberty', 'Prima', 'Priscilla', and 'Freedom' (all scab-resistant) and 'Spur Red Delicious' (Bisbee strain)] to determine consumer opinion of quality. Testers evaluated fruit for specific quality attributes (texture, juiciness, aroma, tartness, and sweetness) and overall quality in a random, blind taste test in 1988 (60 testers) and 1989 (48 testers). The testers were volunteers at a local apple festival (Terhune Orchards, Princeton, N.J.) on 30 Sept. 1988 and 3 Oct. 1989. In 1988, the 'Spur Red Delicious' had a 9% soluble solids concentration (SSC), but was included as an unacceptable

cultivar to determine if consumers could identify a low-quality apple. 'Priscilla' was harvested late, had little firmness (48 N), but was included as our low-quality standard with respect to texture. Fruit for testing was prepared by peeling, slicing into 6-mm pie slices, and dipping in a solution of ascorbic acid to prevent discoloration. During the test, fruit temperature was ≈ 20°C. Each tester was given three randomly assigned apple slices to evaluate for quality attributes. An evaluation scale was developed following that proposed by Dhanaraj et al. (1980). Descriptions appropriate for each of the five quality attributes ranged from less desirable characteristics at each end of the scale to a mid-range optimum (Table 1). If an attribute fell between a description, the taster indicated this on the evaluation form.

**Overall quality evaluation** Alter rating each sample for the five quality attributes, an overall rating of excellent (1), very good (2), good (3), fair (4), or poor (5) was made. A bite of saltless cracker and a sip of water was taken between samples to cleanse the palate.

**Cultivar preference.** Each tester was given three sets of three randomly assigned slices and asked to indicate their preference for best, acceptable, and least acceptable. A bite of cracker and a sip of water was taken between sets.

**Visual attributes.** Testers evaluated five fruit for color, shine, shape, and overall appearance by indicating whether the fruit was attractive, fair, or poor for each attribute.

Fruit firmness (see Table 2) was measured in the laboratory the day before taste testing each year by use of a 11-mm plunger tip on a McCormick Fruit Tester (FT327; Effegi, Alfonsine, Italy) on each of 10 fruit/cultivar. Soluble solids concentration was determined using a hand-held refractometer (Atago, Japan) on each of 10 fruit/cultivar each year (Table 2). Firmness and SSC are objective correlates of subjective ratings of fruit quality. While optimum firmness and SSC vary with cultivar, a general range for acceptable values is 59 to 98 N, and 10% to 15%, respectively. It would have been desirable to obtain samples of fruit from several orchards; however, since the cultivars we used are not widely planted, we were limited to one source for each cultivar. Fruit were harvested using commercial harvesting guidelines (Childers, 1978) unless otherwise noted.

Statistical analysis of the quality evaluations, cultivar preference, and visual evaluations were performed by assigning numerical values to the various categorical answers (Table 1). The ratings were then subjected to a Kruskal-Wallis test (1952), a nonparametric

Table 1. Scale used for sensory evaluation of disease-resistant apple cultivars using an untrained panel. Numerical scores were not included on the original form; they serve to interpret values presented in Table 2.

Attribute	Attribute description		
	Undesirable (1)	Desirable (2)	Undesirable (3)
Texture	Hard, starchy	Firm, crisp	Very soft, mealy
Juiciness	Too juicy, watery	Juicy, full-bodied	Dry
Aroma	None	Nice fruity	Excessive
Taste	Sour, tart, sharp	Pleasant	Excessive
Sweetness	None	Pleasant	Excessive

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Table 2. Objectively and subjectively (ratings) measured quality attributes of four disease-resistant apple cultivars as evaluated by an untrained panel in 2 years.

Cultivar	Objective measures		Panel ratings <sup>z</sup>					Overall
	Firmness (N)	SSC (%) <sup>y</sup>	Texture	Juiciness	Aroma	Taste	Sweetness	
<i>1988</i>								
Freedom	74 b*	13.4 a	2.03 b	2.26 a	1.52 b	1.52 c	1.67 c	1.08 d
Liberty	99 a	13.3 a	1.81 c	2.19 a	1.58 ab	1.45 c	1.72 bc	2.57 c
Prima	78 b	11.5 b	2.14 b	2.03 a	1.57 ab	1.86 b	1.86 ab	2.56 c
Priscilla	48 c	11.8 b	2.77 a	2.13 a	1.69 a	1.90 b	1.88 a	3.08 b
Delicious	76 b	9.0 c	2.00 b	2.10 a	1.30 c	2.59 a	1.49 d	3.74 a
<i>1989</i>								
Freedom	81 a	13.3 a	2.03 c	2.06 a	1.76 a	1.79 c	1.83 a	2.69 d
Liberty	91 a	13.1 a	1.82 d	1.96 a	1.55 b	1.43 d	1.67 b	2.88 cd
Prima	81 a	11.4 c	2.24 b	1.94 a	1.43 b	2.02 b	1.63 b	3.06 bc
Priscilla	62 b	13.0 ab	2.57 a	1.82 a	1.73 a	1.90 bc	1.91 a	3.45 a
Delicious	66 b	11.6 bc	2.05 c	2.09 a	1.49 b	2.44 a	1.64 b	3.30 ab

Ratings: 2 = optimum for texture, juiciness, aroma, taste, and sweetness; 1 or 3 = undesirable. Overall ratings: 1 = excellent, 5 = poor.

<sup>y</sup>SSC = soluble solids concentration.

<sup>z</sup>Mean separation within columns using a protected LSD for firmness and SSC and Miller's multiple comparison procedure for Kruskal-Wallis scores for quality attributes. Both separations are at  $\alpha = 0.05$ . Values are means of 60 samples in 1988 and 48 samples in 1989.

analysis. Cultivar means were separated using Miller's (1966) multiple comparison procedure for Kruskal-Wallis rank sums. Firmness and SSC data were analyzed with a one-way analysis of variance, and mean separation performed using Fisher's protected LSD.

**Taste tester profile.** Males and females were equally represented in the tests. Thirty-two percent of the testers were younger than 20 years, 18% were between the ages of 21 and 30, 28% were between 31 and 40, 10% between 41 and 50, and 12% were 51 years or older. Sixty-five percent of the testers earned less than \$40,000 annually, while 35% earned

more than that. Among the testers, 25% said they consumed, on average, less than one piece of fruit per day, 37% consumed one piece per day, and 38% consumed two or more pieces per day. Apples were most preferred by 50% of the testers, 18% preferred bananas, and 15% preferred grapes. The remaining 17% were equally divided in their preference of peaches, pears, and oranges.

**Texture.** In 1988, 'Freedom', 'Prima', and 'Red Delicious' were considered firm and crisp (Table 2). 'Liberty' was harder than 'Freedom', 'Prima', or 'Red Delicious', but not undesirable. Its mean rating was 0.2 less than optimum. 'Priscilla' was undesirable, soft, and mealy, as expected, since 'Priscilla' had low firmness according to the objective test in 1988. In 1989, 'Freedom' and 'Red Delicious' were optimally firm and crisp; 'Prima' was slightly softer. 'Priscilla' was again perceived as soft and mealy, although it was no less firm than 'Red Delicious' by the objective test (Table 2). 'Liberty' was hard, but acceptable.

**Juiciness.** Testers could not discern differences in juiciness among cultivars in either year.

**Aroma.** In 1988, 'Priscilla' was more aromatic than 'Freedom' or 'Red Delicious'. 'Red Delicious' was less aromatic than any other cultivar. In 1989, 'Freedom' and 'Priscilla' were more aromatic than 'Liberty', 'Prima', or 'Red

Delicious'. None of the cultivars was excessively aromatic in either year. Testers commented that they had a difficult time determining aromaticity.

**Flavor.** 'Freedom' and 'Liberty' were considered sour, tart, or sharp both years. In 1989, 'Liberty' was judged sharper than 'Freedom'. 'Red Delicious' was bland both years. 'Prima' and 'Priscilla' were pleasant.

**Sweetness.** In 1988, 'Red Delicious' lacked sweetness. 'Prima' and 'Priscilla' were nearly optimum followed by 'Liberty' and 'Freedom'. In 1989, 'Liberty', 'Prima', and 'Red Delicious' were not as sweet as 'Freedom' or 'Priscilla'.

**Overall quality.** In 1988, 'Freedom' was judged excellent in overall quality; 'Liberty' and 'Prima' were good to very good; 'Priscilla' was good to fair; and 'Red Delicious' was fair. In 1989, 'Freedom' and 'Liberty' were good to very good; 'Prima' was good; and 'Priscilla' and 'Red Delicious' were fair to good. In 1989, 'Freedom', 'Liberty', and 'Prima' were good to excellent in quality, while 'Priscilla' was not.

**Cultivar preference.** 'Freedom', 'Liberty', and 'Prima' had higher preference ratings than 'Priscilla' and 'Red Delicious', and 'Priscilla' had a higher one than 'Red Delicious' in 1988 (Table 3). In 1989, 'Freedom' had the highest preference rating followed by 'Liberty', 'Prima', 'Red Delicious', and 'Priscilla'. Thus, consumers rated two of the four DRCs higher than the standard 'Red Delicious'. The first year we expected this, since the standard was of poor quality. The second year's test was a fairer assessment. The standard was similar to the DRCs in SSC and firmness (Table 2).

**Color.** In 1988, 'Liberty' was the most attractively colored cultivar (Table 4). The rest differed little. In 1989, 'Liberty' and 'Prima' were most attractively colored. 'Red Delicious' was least attractive, with the others intermediate.

**Shine.** In 1988, 'Freedom', 'Liberty', 'Prima', and 'Red Delicious' were shinier than 'Priscilla'. In 1989, 'Prima' was the shiniest cultivar.

**Shape.** In 1988, 'Freedom', 'Liberty', and 'Red Delicious' had slightly more attractive shapes than 'Priscilla'. The shape of 'Prima'

Table 3. Mean preference ratings of disease-resistant apple cultivars as best (1), acceptable (2), or worst (3), as determined by untrained taste testers in 1988 and 1989.

Cultivar	Preference rating	
	1988	1989
Freedom	1.81 c <sup>z</sup>	1.63 d
Liberty	1.61 c	1.83 c
Prima	1.78 c	2.05 b
Priscilla	2.22 b	2.25 a
Delicious	2.52 a	2.12 b

<sup>z</sup>Mean separation within year using Miller's multiple comparison procedure for Kruskal-Wallis scores,  $\alpha = 0.05$ . Values are means of 163 samples in 1988 and 130 samples in 1989.

Table 4. Mean appearance characteristic ratings of disease-resistant apple cultivars as (1) attractive, (2) fair, and (3) poor as evaluated by untrained testers in 1988 and 1989.

Cultivar	Appearance			Overall
	Color	Shine	Shape	
<i>1988</i>				
Freedom	1.77 b <sup>z</sup>	1.53 b	1.45 b	1.63 b
Liberty	1.39 c	1.59 b	1.40 b	1.45 b
Prima	1.86 ab	1.45 b	1.57 ab	1.64 b
Priscilla	2.14 a	1.96 a	1.77 a	2.11 a
Delicious	1.79 b	1.66 b	1.39 b	1.63 b
<i>1989</i>				
Freedom	2.3 a	2.2 a	1.9 a	2.2 a
Liberty	1.3 d	1.5 c	1.4 b	1.3 d
Prima	1.3 d	1.2 d	1.3 b	1.3 d
Priscilla	1.8 b	1.9 b	1.8 a	1.8 b
Delicious	1.6 c	1.8 b	1.4 b	1.5 c

<sup>z</sup>Mean separation within column and year by Miller's multiple comparison procedure for Kruskal-Wallis scores,  $\alpha = 0.05$ . Values are means of 101 samples in 1988 and 97 samples in 1989.

was judged as similar to that of the other cultivars. In 1989, 'Liberty', 'Prima', and 'Red Delicious' were fair to attractively shaped. 'Freedom' and 'Priscilla' were rated as fair.

*Overall appearance.* In 1988, 'Priscilla' was poor to fair in overall appearance. All other cultivars were fair to attractive in overall appearance. In 1989, 'Liberty' and 'Prima' were most attractive followed by 'Red Delicious'. 'Freedom' was least attractive.

Two of the four DRCs tested were acceptable to the consumer in both years. Consumers did not find 'Priscilla' acceptable; it was not attractive and did not receive a high preference rating. Ratings for flavor and quality of 'Priscilla' were also low in both years. 'Freedom' was most acceptable for flavor and quality both years, while 'Liberty' and 'Prima' were acceptable.

Of the four DRCs tested, consumers gave the highest preference rating to 'Freedom'. 'Liberty' received nearly as high a preference rating as 'Freedom'. 'Freedom' did have the drawback of being unattractive in 1989. 'Liberty' was attractive both years. Untrained taste testers can be used to discern differences in apple cultivar quality. They were consistent in evaluating quality and preference; the cultivars with the highest quality ratings, 'Liberty' and 'Freedom', were also those with the highest preference ratings in both years. Apples used in these taste tests were freshly harvested; thus, these results should only be interpreted for fruit that will be consumed soon after harvest. Additionally, we had only one source for each cultivar, when, ideally, fruit from several sources should be used in a taste test.

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