Determination of Optimum Maturity for Several Apple Cultivars Grown in Minnesota[1]

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A significant segment of the apple production industry in Minnesota and nearby north central states is based on cold resistant cultivars which are not grown extensively in other production areas. Consequently, there has been little if any research conducted on defining optimum maturity for harvest other than subjective field estimations based on color, taste, fruit drop, etc. The purpose of this study was to determine optimum harvest maturity by testing some of the most commonly used indicators such as firmness and soluble solids at different harvest dates and relating these data to fruit quality and storage potential for several hardy cultivars plus McIntosh as a standard.

Flesh firmness, as measured with a pressure tester, has been used in experiments dealing with the earliest acceptable harvest date (1), overripeness (3), pre-storage heating (9), delay in storage to reduce breakdown (7), and growth regulator applications (8). During the harvest season, a pressure tester has been useful in determining the condition of fruit for safe storage versus immediate market (2). A soluble solids measurement, when combined with a firmness reading (10) or with a % acid content (5) has been found useful in setting harvest guidelines for some strains of Red Delicious.

MATERIALS AND METHODS

Fruit from eight cultivars, Haralson, Honeygold, Keepsake, McIntosh, Red Baron, Red Fireside, Regent and Sweet Sixteen, were collected at 5 day intervals on 5 consecutive harvest dates in the fall of 1978. The third, median date corresponded to the average maturity date as determined from data collected at the Horticultural Research Center, Excelsior, over the past 20 years. Fruit was placed in cold storage, 1° to 2°C, immediately after harvest. Two objective maturity tests were conducted at harvest and 70-89 days after harvest: firmness (Kg), using an Effe-gi pentrometer; and soluble solids (S.S.), using a hand held refractometer (American Optical Model No. 10430). In addition, a sensory evaluation was performed by a panel of six trained individuals in late November for McIntosh and Regent and for the other cultivars during early February, 1979. Panelists were asked to rate fruit on the basis of skin color, flesh color, degree of watercore, texture, flavor and aroma, and overall quality. A scoring range of 1 to 9 was used with one being the lowest. A score of 4 or lower was used for unacceptable entries.

RESULTS AND DISCUSSION

Red Baron

The pressure data revealed a significantly higher firmness value for apples harvested on September 10, the first harvest date, than for apples from the last four harvest dates (Table 1). Similar results were found after 87 days of storage. No fruit drop occurred during the twenty day collection period nor did any storage disorders develop.

Sweet Sixteen

Although the sensory panel did not detect significant differences in stored

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fruit from different harvest dates, firmness was highest from the first harvest date (Sept. 13) on all three sampling dates. Further tests are needed to determine if even earlier harvest would improve fruit firmness and maintain quality in storage.

Table 1. Flesh firmness of Red Baron apples harvesed at five consecutive, equal intervals and evaluated after 20, 100 and 185 days of storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/1/78	2nd Evaluation 12/18/78	3rd Evaluation 3/19/79
9/10	11.7a[1]	6.9a	6.2a
9/15	9.9b	6.0b	6.0a
9/20	9.9b	6.2b	5.2b
9/25	9.6b	6.1b	6.1a
9/30	9.7b	6.1b	5.4b

[1]Duncan's Multiple Range Test for means within evaluation date at 5% level of significance.

Table 2. Flesh firmness of Sweet Sixteen apples harvested on five consecutive, equal intervals and evaluated after 20, 98, and 187 days storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/3/78	2nd Evaluation 12/19/78	3rd Evaluation 3/18/79
9/13	15.6a[1]	7.8a	7.3a
9/19	13.8b	7.3ab	6.7b
9/23	14.0b	7.4ab	6.8b
9/28	13.1bc	7.1bc	6.3c
10/3	12.2c	6.7c	6.3c

[1]Duncan's Multiple Range Test for means within evaluation date at 5% level of significance.

Table 3. Flesh firmness of McIntosh apples harvested on five consecutive, equal intervals and evaluated after 21, 86, and 176 days of storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/6/78	2nd Evaluation 12/20/78	3rd Evaluation 3/20/79
9/15	12.3a[1]	5.8a	5.5a
9/20	10.8b	5.9a	5.1a
9/25	9.9bc	5.9a	5.4a
9/30	9.9bc	5.8a	5.0a
10/5	9.3c	5.7a	3.8b

[1]Duncan's Multiple Range Test for means within evaluation date at 5% level of significance.

McIntosh

McIntosh fruit firmness dropped by more than 50% between the initial harvest date and the second evaluation 86 days later. The first two harvest dates 9/15 and 9/20 produced the firmest fruit with the least bruising but sensory quality after 70 and 147 days of storage was best for the late harvest dates. This illustrates a major handling problem with this cultivar, early harvest is essential for handling durability but later harvest is desirable for flavor development. The low fruit firmness with McIntosh encountered in this study is unusual and may be related to fertility or environmental circumstances beyond our control.

Although McIntosh has a good market for top quality fruit this study underscores grower opinions that McIntosh is a difficult apple to handle. Fruit storage disorders, McIntosh breakdown, scald and brown core were also detected in stored fruit in this study. Fruit drop was pronounced by the October 5 harvest date.

Table 4. Sensory evaluation scores for McIntosh apples after 70 and 147 days of storage. Average scores evaluated by five panelists (1-4 not acceptable; 5-6 fair; 7-9 good).

	Skin Color	Flesh Color	Overall Fresh Fruit Quality	
Harvest Date	147 days	147 days	70 days	147 days
9/15/78	5.4c[1]	5.5b	5.4b	5.5c
9/20/78	5.9bc	5.7b	6.0ab	5.5c
9/25/78	6.6ab	6.8a	6.1a	5.8bc
9/30/78	6.9a	6.6a	6.7a	6.7a
10/5/78	6.9a	5.5b	6.1a	6.0a

[1]Mean separation within columns by Duncan's Multiple Range Test, 5% level.

Haralson

Fruit from the first harvest date 9/26 was the firmest at harvest but by the second and third evaluations there were no differences in storage. Brix means did not differ significantly nor did the panel detect any differences in sensory quality after 109 days storage. This implies a relatively wide latitude in harvest time is available to the

grower without appreciable impact on storage quality. No fruit drop occurred during the 20 days harvest span but brown core and skin shrivelling were detected in storage.

Table 5. Flesh firmness of Haralson apples harvested on five consecutive, equal intervals evaluated after 20, 81 and 166 days in storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/2/78	2nd Evaluation 12/18/78	3rd Evaluation 3/19/79
9/26	11.7a[1]	9.2ab	8.0a
10/2	11.4ab	9.1ab	8.0a
10/6	10.8b	8.8b	—
10/11	10.8b	9.6a	8.3a
10/16	10.8b	9.6a	8.5a

[1]Mean separation by Duncan's Multiple Range Test within evaluation dates, 5% level of significance.

Honeygold

Evaluation of firmness 20 days after harvest showed that the second and third harvest dates (October 1 and 6) produced the firmest fruit. During the second evaluation (81 days storage), the first harvest date produced the firmest fruit and no differences were found after 166 days storage. Brix means did not differ among harvest dates. Later harvest dates generally resulted in greater bruising injury. The sensory panel did not detect any differences in quality after 105 days of storage among fruit harvested on different dates. No fruit drop occurred during the harvest period. Some senile brown core occurred in stored fruit but was not related to harvest date.

Table 6. Flesh firmness of Honeygold apples harvested on five consecutive, equal intervals and evaluated after 21, 72 and 166 days in storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/21/78	2nd Evaluation 10/21/78	3rd Evaluation 3/22/79
9/29	10.3ab[1]	7.7a	6.3a
10/1	10.6a	7.2b	6.0a
10/6	10.6a	7.1b	5.7a
10/11	9.7b	7.1b	5.9a
10/16	8.9c	6.3c	6.1a

[1]Mean separation by Duncan's Multiple Range Test within evaluation dates, 5% level of significance.

Keepsake

This new cultivar was released because of its history of excellent storage capability. In this test initial pressure readings were very high, dropped appreciably after 75 days storage but only slightly after 161 days storage. Brix readings did not differ at harvest but were highest in storage from the latest harvest dates. Although the highest scores were from the latest harvest dates, the sensory panel could discern no significant differences due to harvest date for any of the characteristics evaluated. There was no fruit drop or storage disorder. This cultivar has a wide latitude in harvest date.

Table 7. Flesh firmness of Keepsake apples harvested on five consecutive, equal intervals and evaluated after 21, 75 and 161 days storage.

	Pressure (lb/0.15 in²)		
Harvest Date	1st Evaluation 10/22/78	2nd Evaluation 12/26/78	3rd Evaluation 3/22/79
10/1	17.9a[1]	10.2bc	9.3a
10/7	16.4b	11.2a	9.6a
10/12	16.5b	10.1c	9.1a
10/17	15.5b	11.0ab	8.7b
10/22	16.0b		9.1ab

[1]Mean separation by Duncan's Multiple Range Test within evaluation dates, 5% level of significance.

Regent

Even though fruit from the first harvest date was the firmest at 21 days, after 75 and 162 days storage the last harvest date had the firmest fruit. The last harvest dates also resulted in higher Brix readings after 162 days of storage. Brown core developed from fruit picked on the first three harvest dates. This cultivar definitely benefits from longer maturity on the tree but fruit drop began with the fourth harvest thus a stop drop should be used to optimize harvest and storage quality. Harvest latitude is not as wide as with Haralson or Keepsake. No differences in sensory quality were detected by the panel.

Table 8. Flesh firmness and Brix values of Regent apples harvested on five consecutive, equal intervals and evaluated after 21, 75 and 162 days in storage.

Harvest Date	Pressure (lb/0.15 in²) 1st Evaluation 10/22/78 Pressure	Brix	2nd Evaluation 12/26/78 Pressure	Brix	3rd Evaluation 3/23/79 Pressure	Brix
10/1	12.9a[1]	13.9a	8.7a	13.4a	6.9b	13.2b
10/7	11.7a	14.2a	8.9a	13.6a	7.3b	13.1b
10/12	12.1a	13.9a	8.9a	13.4a	7.1b	13.5ab
10/17	12.1a	14.5a	9.4a	13.4a	7.5b	13.2b
10/22	11.7a	14.5a	9.2a	13.9a	8.1a	14.0a

[1]Mean separation within columns by Duncan's Multiple Range Test, 5% level of significance.

Red Fireside

Firmness values were highest from fruit picked on October 17 for all three evaluation periods. Brix means did not differ significantly but the sensory panel did detect significant quality differences with the October 17 and 22 dates the highest. There was no premature fruit drop and only slight senile brown core with no relationship to harvest date.

SUMMARY

There appears to be a distinction in allowable latitude for length of the harvest interval among cultivars as an impact on storage performance and quality. Some varieties must be harvested within a short time period at well defined, chronological dates, pressure readings, and soluble solids content. Red Baron, Sweet Sixteen and McIntosh should be harvested before a critical drop in flesh firmness to retain storability. Honeygold, Keepsake, Regent and Red Fireside, later ripening cultivars, should be allowed to remain on the tree long enough to develop optimum soluble solids to retain quality in storage. Haralson had the widest latitude in harvest date with little or no effect on storage performance over the 20 day harvest interval used in this study. Harvest latitude might be considered as a valuable trait for breeders to consider in selecting new cultivars to help growers optimize their management program for top quality fruit. Genotype X environment interaction was not assessed in this study and probably has a significant role in determining the expression of this characteristic.

Table 9. Flesh firmness of Red Fireside apples harvested on five consecutive, equal intervals evaluated after 21, 70 and 158 days of storage.

Harvest Date	Pressure (lb/0.15 in²) 1st Evaluation 10/28/78	2nd Evaluation 12/26/78	3rd Evaluation 3/24/79
10/7	12.4a[1]	8.4b	7.4b
10/12	12.0a	8.3b	7.1b
10/17	12.6a	9.1a	7.6ab
10/22	12.0a	8.5b	6.9b
10/27	12.1a	8.3b	8.1a

[1]Mean separation within columns by Duncan's Multiple Range Test, 5% level of significance.

Table 10. Sensory evaluation scores for Red Fireside apples after 122 days of refrigerated storage. Average scores evaluated by five panelists (1-4 not acceptable; 5-6 fair; 7-9 good).

Harvest Date	Texture	Flavor	Overall
10/7	6.5ab[1]	5.4bc	5.7b
10/12	5.6b	5.1c	5.3b
10/17	7.1a	6.6a	7.0a
10/22	7.0a	6.6a	6.7a
10/27	6.2ab	5.1c	5.1b

[1]Mean separation within columns by Duncan's Multiple Range Test, 5% level of significance.

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Explorer — A New Full-Season Japanese-Type Plum for the Southeastern United States

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The Science and Education Administration, USDA, has recently released a new Japanese-type plum named Explorer that is adapted to all areas of the southeastern United States where these plums are grown. The name, Explorer, refers obliquely to the fact that this plum is the first release from the plum breeding project at the USDA Southeastern Fruit and Tree Nut Research Laboratory.

The pedigree of Explorer appears in Fig. 1. The seed, selected by Dr. John Weinberger, originated in 1963 in a California commercial orchard on a Queen Ann tree with Santa Rosa obligated as the pollenizer. The seedling was grown at the Southeastern Fruit and Tree Nut Research Laboratory at Byron, Georgia. After being selected by Mr. Victor Prince in 1967, it was tested as BY4-401 at Byron and five other Southeastern locations. The several species in the genetic background of Explorer all contribute to its salient features. The bright purplish black skin was probably derived from *Prunus simonii* Carr., the amber flesh from *P. americana* Marsh, and most of the high quality attributes of its fruit from the Japanese plum, *P. salicina* Lindl. (Fig. 1 and Table 1).

The trees of Explorer are moderately vigorous. In the early years they are upright with a slight tendency for the branch ends to turn outward to give a slight vase-shape. As the trees come into production, the branches bend down, and in older trees no new upright growth of any significance de-

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