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# Ripening and Storability of 'Marshall McIntosh' Apples[1]

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## Abstract

'Marshall McIntosh,' along with 6 other strains of 'McIntosh,' were planted in a replicated trial in 1979. 'Marshall McIntosh' ripened before 'Rogers McIntosh' each year from 1984 through 1988. Fruit of the 'Gatzke' strain were consistently among the largest, and 'Marshall' fruit were consistently among the smallest. Firmness differences at harvest and after storage could be attributed to fruit size. No differences were noted among the strains with respect to the development of scald, bitter pit, senescent breakdown, or decay after refrigerated or controlled atmosphere storage. However, storage of 'Marshall' and 'Rogers McIntosh' in controlled atmosphere storage with $O_2$ concentrations of 2.25 and 3% showed that 'Marshall' was considerably more sensitive to low $O_2$ levels than was 'Rogers McIntosh.'

## Introduction

In 1985 (1) we reported that 'Marshall McIntosh' colored earlier and more intensively than 6 other strains of 'McIntosh.' Additionally, a slightly earlier ripening was noted for 'Marshall McIntosh' than for the other strains. Because of these characteristics and the recent concern about the safety of daminozide residues on apples, 'Marshall Mcintosh' has gained in importance in the 'McIntosh'-growing regions of the U.S. and Canada. Its earlier coloring and ripening allow a non-chemical expansion of the 'McIntosh' harvest season. However, as with any new strain or cultivar, characteristics such as storability must be assessed carefully to avoid potential future problems. In the study reported here we confirmed the early ripening of 'Marshall McIntosh' and assessed the relative storability of 'Marshall McIntosh' and 6 other strains of 'McIntosh.'

## Materials and Methods

A planting of 'Morspur,' 'Marshall, 'Imperial,' 'Macspur,' 'Eastman,' 'Gatzke,' and 'Rogers McIntosh' on M.7A was established in 1979 at a commercial orchard in Wilbraham, MA (1). The experiment included 8 replications in a randomized complete block design.

Maturity of 'Marshall' and 'Rogers McIntosh' fruit was assessed in 1985-88 using internal ethylene. In 1985, 5-fruit samples were harvested randomly form each of 5 replications on 8-27, 9-3, and 9-10. In 1986 and 1987, 4-fruit samples were harvested randomly from each of 8 replications on 9-4 and 9-3, respectively. In 1988, 5-fruit samples were harvested randomly from each of 8 replications on 9-2. A 1-ml sample of internal atmosphere was extracted from each fruit using a syringe inserted through the calyx opening. The ethylene concentration of this sample was measured using a gas chromatograph equipped with a 0.30 x 50 cm activate alumina column and a flame ionization detector.

Storability assessment was conducted for all strains in 1985-87. Each year at harvest a 10-apple sample was taken at random from each strain in each replication and was used to assess fruit diameter and flesh firmness. Firmness of each of the 10 apples was measured with a Magness-Taylor Pressure Tester at the equator on the red and green sides of each apple. In 1985, 1 20-kg sample was harvested from each tree on 9-10. These fruit were kept in controlled atmosphere (CA)

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storage (3°C, 3% O2, 5% $CO_2$) for 7 months and in refrigerated storage (0°C) for 2 months. Flesh firmness was assessed on a 10-apple sample from each tree after 1 day at room temperature, and the incidences of scald, decay, senescent breakdown, and browncore (2) were determined after 7 days at room temperature. In 1986, 2 20-kg samples were harvested from each tree on 9-4. One sample from each tree was kept in refrigerated storage for 4 months, and the second sample was kept in CA storage for 6 months, followed by refrigerated storage for 1.5 months. For both treatments flesh firmness was assessed on a 10-apple sample from each tree after 1 day at room temperature. The fruit from refrigerated storage were kept at room temperature for 8 days, and those from CA storage were kept at room temperature for 11 days prior to the assessment of the incidences of scald, decay, senescent breakdown, and bitter pit. In 1987, 2 20-kg samples were harvested from each tree on 9-3. One sample from each tree was kept in refrigerated storage for 7 months, and the second sample was kept in CA storage for 6 months, followed by refrigerated storage for 1 month. For both treatments flesh firmness was assessed on a 10-apple sample from each tree after 1 day at room temperature. The fruit from refrigerated storage and from CA storage were kept at room temperature for 12 and 14 days, respectively, prior to assessing the incidences of decay and senescent breakdown.

In 1988, 2 20-kg samples were harvested from each 'Marshall' and 'Rogers McIntosh' tree on 9-2. Both samples were kept in 600-bu CA storages for 6 months; however, one storage was at 2.25% $O_2$ and the other was at 3% $O_2$. Following CA storage, samples were kept in refrigerated storage for 1 month and at room temperature for 6 days prior to determining the incidence of low-$O_2$ injury.

All data were subjected to analysis of variance, and means were separated with Duncan's New Multiple Range Test ($p = 0.05$). For the 1988 storage experiment, sums of squares for strain and the interaction of strain and $O_2$ concentration were repartitioned to represent the effect of strain within each $O_2$ concentration. All percent data were transformed to arcsine prior to analysis.

## Results and Discussion

Figure 1 shows the internal ethylene concentration of 'Marshall' and 'Rogers McIntosh' fruit in 1985-88. As was seen in 1984 (1), at each harvest and in each year 'Marshall' fruit had a significantly higher internal ethylene concentration than did 'Rogers McIntosh,' suggesting that 'Marshall McIntosh' were entering the ethylene climacteric before 'Rogers.' At harvest over all years and samples, 34% of the 'Marshall' fruit and 21% of the 'Rogers' fruit had entered the ethylene climacteric (internal concentration <1ppm) (data not shown). This earlier ripening and the earlier and more intense coloring of 'Marshall McIntosh' (1) suggest that it can be used to advance the 'McIntosh' harvest season.

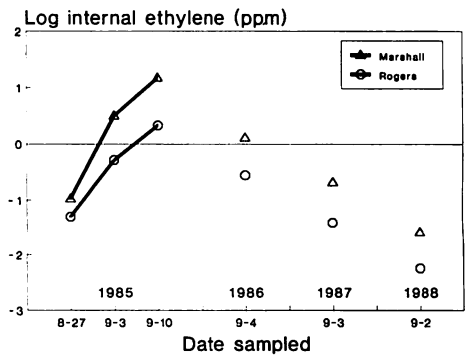


**Figure 1. Internal ethylene concentrations at harvest in 1985-88 of 'Marshall' and 'Rogers McIntosh' fruit. At each harvest 'Marshall McIntosh' fruit had significantly higher ($p = 0.05$) internal ethylene than 'Rogers McIntosh' fruit.**

**Table 1. Diameter and flesh firmness at harvest of fruit from 7 'McIntosh' strains in 1985, 1986, and 1987.[z]**

| Strain | Fruit diameter (cm) | | | Flesh firmness (N) | | |
|---|---|---|---|---|---|---|
| | 1985 | 1986 | 1987 | 1985 | 1986 | 1987 |
| Morspur | 8.18 b | 7.72 b | 7.39 ab | 62.3 ab | 65.8 a | 83.6 ab |
| Marshall | 7.87 c | 7.49 c | 7.24 b | 64.1 a | 65.8 a | 85.0 a |
| Imperial | 8.18 b | 8.00 a | 7.47 a | 62.7 ab | 64.9 ab | 81.8 bc |
| Macspur | 8.26 b | 7.75 b | 7.37 ab | 58.3 c | 63.6 c | 79.2 d |
| Eastman | 8.36 ab | 8.13 a | 7.44 a | 61.4 b | 63.2 c | 80.5 cd |
| Gatzke | 8.61 a | 8.03 a | 7.49 a | 59.2 c | 64.1 bc | 81.0 cd |
| Rogers | 8.05 bc | 7.70 b | 7.32 ab | 63.6 ab | 65.4 ab | 83.6 ab |

[z]Mean separation within columns by Duncan's New Multiple Range Test (p = 0.05).

Table 1 shows the diameter of fruit of the 7 strains in 1985-87. Fruit from the 'Gatzke' strain consistently were among the largest. Fruit from the 'Marshall' strain consistently were among the smallest, but they were significantly smaller than 'Rogers' fruit only in 1 of 4 years [3 years reported here and one by Lord et al. (1)]. Table 1 also shows the flesh firmness at harvest in 1985-88. In general the largest fruit tended to be the least firm and the smallest the most firm. These differences generally were carried through the storage treatments (Tables 2 and 3).

Tables 2 and 3 show the incidences of storage disorders after refrigerated and CA storage. In no case was there any significant difference among

**Table 2. Flesh firmness and the incidences of disorders of 7 strains of 'McIntosh' after refrigerated storage at 0°C in 1986 and 1987.[z]**

| Strain | Flesh firmness (N) | Scald (%) | Decay (%) | Senescent breakdown (%) | Bitter pit (%) |
|---|---|---|---|---|---|
| | | 1986 | | | |
| Morspur | 44.9 ab | 6 | 8 | 11 | 5 |
| Marshall | 44.5 ab | 6 | 9 | 7 | 1 |
| Imperial | 43.6 ab | 10 | 8 | 15 | 4 |
| Macspur | 40.9 b | 3 | 7 | 11 | 3 |
| Eastman | 41.4 ab | 9 | 7 | 11 | 5 |
| Gatzke | 40.5 b | 9 | 22 | 12 | 5 |
| Rogers | 45.8 a | 8 | 11 | 6 | 2 |
| | | 1987 | | | |
| Morspur | 48.0 ab | -- | 19 | 7 | -- |
| Marshall | 48.9 a | -- | 16 | 2 | -- |
| Imperial | 48.5 a | -- | 10 | 4 | -- |
| Macspur | 44.5 c | -- | 21 | 10 | -- |
| Eastman | 45.8 bc | -- | 16 | 8 | -- |
| Gatzke | 46.7 b | -- | 23 | 6 | -- |
| Rogers | 47.6 ab | -- | 18 | 8 | -- |

[z]Mean separation within column and year by Duncan's New Multiple Range Test (p = 0.05). Where no letters appear after the means, strain effects were nonsignificant.

**Table 3. Flesh firmness and the incidences of disorders of 7 strains of 'McIntosh' after CA storage (3%, $O_2$, 5% $CO_2$) at 3°C in 1985, 1986, and 1987.[z]**

| Strain | Flesh firmness (N) | Scald (%) | Decay (%) | Senescent breakdown (%) | Bitter pit (%) | Browncore (%) |
|---|---|---|---|---|---|---|
| | | | 1985 | | | |
| Morspur | 43.6 | 0 | 17 | 14 | -- | 3 |
| Marshall | 44.9 | 0 | 28 | 23 | -- | 0 |
| Imperial | 45.8 | 0 | 13 | 15 | -- | 1 |
| Macspur | 38.7 | 0 | 30 | 27 | -- | 0 |
| Eastman | 44.5 | 0 | 27 | 14 | -- | 0 |
| Gatzke | 42.7 | 0 | 22 | 25 | -- | 1 |
| Rogers | 42.7 | 1 | 14 | 19 | -- | 1 |
| | | | 1986 | | | |
| Morspur | 47.6 bc | 2 | 3 | 2 | 5 | -- |
| Marshall | 51.6 a | 2 | 2 | 1 | 2 | -- |
| Imperial | 48.0 bc | 4 | 2 | 0 | 6 | -- |
| Macspur | 45.8 c | 1 | 3 | 1 | 4 | -- |
| Eastman | 50.3 ab | 1 | 6 | 2 | 3 | -- |
| Gatzke | 49.8 ab | 3 | 3 | 1 | 3 | -- |
| Rogers | 49.4 ab | 1 | 2 | 1 | 2 | -- |
| | | | 1987 | | | |
| Morspur | 55.2 b | -- | 4 | 1 | -- | -- |
| Marshall | 58.7 a | -- | 2 | 3 | -- | -- |
| Imperial | 55.6 b | -- | 1 | 0 | -- | -- |
| Macspur | 53.4 c | -- | 3 | 1 | -- | -- |
| Eastman | 56.5 b | -- | 4 | 1 | -- | -- |
| Gatzke | 55.2 b | -- | 4 | 0 | -- | -- |
| Rogers | 54.7 b | -- | 1 | 1 | -- | -- |

[z]Mean separation within column and year by Duncan's New Multiple Range Test ($p = 0.05$). Where no letters appear after the means, strain effects were nonsignificant.

strains in the development of scald, decay, senescent breakdown. bitter pit, or browncore.

Reports from growers suggesting a higher incidence of off-flavors and other low-$O_2$ injuries in 'Marshall McIntosh' than in other 'McIntosh' strains prompted us to establish a trial in 1988 using 2 $O_2$ concentrations (2.25% and 3%) for a comparison of low $O_2$-sensitivity of 'Marshall' and 'Rogers McIntosh.' Figure 2 shows the level of low-$O_2$ injury to 'Marshall' and 'Rogers McIntosh' at each $O_2$ concentration. the low-$O_2$ injury developed as a browning of the outer cortex with a thin layer of normal-appearing tissue just below the skin (Figure 3). When severe, the injury resulted in a sunken area visible on the surface of the fruit. Even at 3% $O_2$ (the recommended level for CA storage of 'McIntosh' in New England) 'Marshall McIntosh' fruit exhibited some internal low-$O_2$ injury. At 2.25% $O_2$, 32% of the 'Marshall' fruit exhibited internal low-$0_2$ injury, while only 4% of the 'Rogers' fruit were damaged. This increased level of damage would represent a significant loss by a storage operator. Additional symptoms noticed in nearly all fruit showing internal symptoms were a

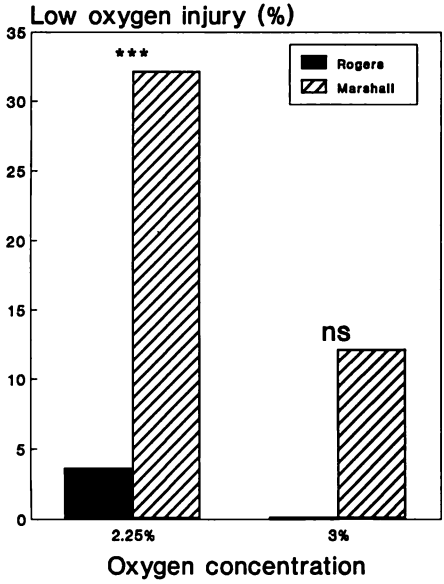


**Figure 2. The incidence of low-$O_2$ injury in 'Marshall' and 'Rogers McIntosh' fruit stored at 3% and 2.25% $O_2$ after the 1988 harvest. At 2.25% $O_2$, significantly more 'Marshall McIntosh' fruit showed low-$O_2$ injury than did 'Rogers McIntosh' fruit; however, no significant difference was seen between the 2 strains at 3%.**

purpling of the skin and an off-flavor. This result clearly shows that storage operators must monitor their $O_2$ concentrations carefully and not allow $O_2$ to drop below the recommended value if they are storing 'Marshall McIntosh' fruit.

In conclusion, 'Marshall McIntosh' may prove to be a great benefit to the 'McIntosh' apple industry with its early coloring and ripening; however, the CA storage of 'Marshall McIntosh' may present some problems. We believe that storage operators who maintain their $O_2$ levels at 3% or above will not have significant problems with 'Marshall McIntosh.'

## Literature Cited

1. Lord, W. J., W. J. Bramlage, and W. R. Autio. 1985. The Marshall McIntosh apple. Fruit Var. J. 39:37-41.
2. Smock, R. M. 1977. Nomenclature for internal storage disorders of apples. HortScience 12:306-08.

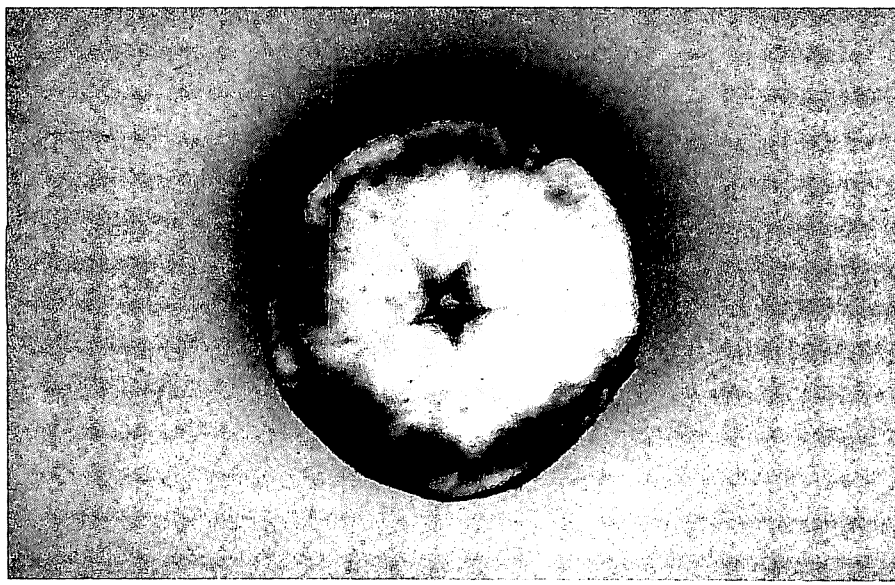

**Figure 3. Internal low-$O_2$ injury in 'McIntosh' apples.**