ephon tended to be somewhat greater than that of fruit treated with a high ion of ethephon. This difference in ect of ethephon concn became less lent as the treatments were applied ther into Stage III. All concn proed the same effect when applied late Stage III (treatment time 6).

During harvest of individual berries, point of release was most often at juncture of the peduncle and pedicel h the treated fruit, rather than at the berry and pedicel juncture as was the case for the control fruit.

Literature Cited

1. Ballinger, W. E., E. P. Maness, G. J. Galletta and L. J. Kushman. 1972. Anthocyanins of ripe fruit of a "pink-fruited" hybrid of highbush blueberries, *Vaccinium corymbosum* L. *J. Amer. Soc. Hort. Sci.* 97:381-384.
2. Darrow, G. M. and J. N. Moore. 1966. Blueberry growing. *U. S. Dept. Agr. Farmers' Bul.* 1951 (revised).
3. Eck, P. 1970. Influence of Ethrel upon highbush blueberry fruit ripening. *HortScience* 5:23-25.
4. Kushman, L. J. and W. E. Ballinger. 1963. Influence of season and harvest interval upon quality of 'Wolcott' blueberries grown in eastern North Carolina. *Proc. Amer. Soc. Hort. Sci.* 83:395-405.
5. Young, R. S. 1952. Growth and development of the blueberry fruit (*Vaccinium corymbosum* L. and *V. angustifolium* Ait.). *Proc. Amer. Soc. Hort. Sci.* 59:167-172.

Quality of 'Stayman Winesap' Apples Stored in Air, Controlled Atmospheres, or Controlled Atmospheres Followed by Storage in Air[1]

R. E. Anderson and R. W. Penney[2]

U. S. Department of Agriculture, Beltsville, Maryland

Abstract. **Taste panelists preferred ayman Winesap' apples stored for 9 months a controlled atmosphere (CA) to those red in air. Apples stored in CA followed by rage in air were generally intermediate in ality (taste, firmness, and acidity) between it stored in CA and those stored in air. hen the fruit were stored for 9 months, the ger they had been in CA before shifting em to air, the more closely they approached e quality and metabolic state of fruit stored months in CA.**

Many apple cultivars retain better ality when they are stored in CA than hen stored in air, however, quality fferences between CA and air stored ples are not evident until the fruit ve been stored several months (3). rther, CA storage extends the elf-life of apples upon their removal air at temp above those in storage). However, information is lacking on e persistence of the benefits of CA orage for apples during their bsequent holding in air at the CA orage temp, such as occurs when a CA om is opened and only a portion of e fruit is marketed. To obtain such formation, we periodically evaluated e quality of apples stored 9 months in r, in CA, or in CA followed by storage air.

'Stayman' apples were obtained on e day of harvest from 3 orchards, 1 in aryland and 2 in West Virginia. The ples were brought to Beltsville and fruit lots from each orchard were randomized into each storage treatment. The fruit were stored at 0°C in CA or air for 3, 5, 7 or 9 months or in CA for 3, 5, or 7 months followed by storage in air for 6, 4 and 2 months, respectively.

At harvest, fruit firmness ranged from 7.4 to 8.3 kg (16.4 to 18.2 lb.), respiration rate from 14.4 to 16.0 mg/kg-hr, and acidity (as malic acid) from 450 to 526 mg/100 ml.

All fruit were in their respective test atmospheres of air or CA at 0°C within 3 days of harvest. Fiberglass chambers (595 liter) and metal drums (114 liter) were used as test chambers. The desired CA (2.5% CO_2 - 3% O_2) was obtained initially by flushing the sealed chambers containing the fruit with N_2 and by adding CO_2. Air flow through the chambers was adjusted to provide the O_2 required for respiration and a flow of N_2 from a cylinder was used to adjust the CO_2 concn when necessary. The flow rates varied from about 0.5 to 10 liter per hr, which did not exceed 3 gas volume changes per chamber per week. The gas concn were monitored with an Orsat-type analyzer and they averaged 2.3% CO_2 and 3.1% O_2 during the test.

The apples were examined at removal from storage and after 1 week in air at 18.3 ± 0.5°C. Fruit respiration was determined (2) during holding in air. One week after storage, firmness and acidity were measured (1) and a taste panel evaluated the apples for firmness, tartness and preference on a scale of 9 to 1, where 9 was the firmest, tartest or most preferred.

Apples that had been stored in CA respired more slowly than those from storage in air, and they were firmer after each storage period plus 1 week in air. Neither respiration nor firmness changed significantly during storage (Table 1). However, the acidity of apples stored in CA was higher than that of apples stored in air from the 5th month on, and it decreased more slowly in the CA fruit (Table 1). These results with 'Stayman' agree with reports on other cultivars (1, 4, 5, 6, 7, 8, 9).

Taste panelists rated apples stored in CA higher in firmness, tartness and preference to those stored in air after each storage period (Table 2). Ratings of firmness and preference did not change significantly during storage, but the panelists did find a significant decrease in tartness between the 3rd and 9th month for apples stored in air, but not for those from CA storage.

Shifting 'Stayman' apples from CA to air storage resulted in a gradual increase in respiration rate. This increase was related inversely to the duration of

Table 1. Respiration rate, firmness, and acidity of 'Stayman' apples after storage in CA or air at 0°C[z].

Storage period (months)	Respiration[y] (mg CO_2/kg-hr)		Firmness[x] (kg)		Acidity[x] (mg/100 ml)	
	CA	Air	CA	Air	CA	Air
3	11.7 b	20.5 a	6.2 a	4.8 c	424 a	427 a
5	12.2 b	18.8 a	6.5 a	5.3 bc	429 a	368 b
7	10.1 b	18.9a	6.1a	4.7 c	415 a	341 bc
9	11.4 b	19.4 a	5.8 ab	4.6 c	372 b	304 c
Mean	11.4 b	19.4 a	6.1 a	4.9 b	410 a	360 a

[z]Mean separation for each factor by Duncan's multiple range test, 5% level.

[y]Respiration in air at 18.3°.

[x]After storage plus 1 week in air at 18.3°.

Received for publication March 29, 1973.

Research Horticulturist and Research Mechanical Engineer, respectively, Agricultural Marketing Research Institute.

The authors wish to thank H. W. Hruschka for his advice regarding the statistical analyses, Barbara Aulenbach for her assistance with the taste panels, and George Brown and Richard Lee for their help in conducting these tests.

Table 2. Taste panel evaluations of 'Stayman' apples after storage in CA or air at 0°C plus 1 week in air at 18.3°C[z]

Storage period (months)	Rating[z] Firmness		Tartness		Preference	
	CA	Air	CA	Air	CA	Air
3	6.3 a	3.7 b	5.8 a	4.3 b	5.8 a	4.1 b
5	6.4 a	3.7 b	5.8 a	4.0 bc	5.5 a	3.6 b
7	6.2 a	3.7 b	5.6 a	3.7 bc	5.5 a	3.3 b
9	5.7 a	3.2 b	5.4 a	3.6 c	5.7 a	3.1 b
Mean	6.1 a	3.6 b	5.6 a	3.9 b	5.6 a	3.5 b

[z]Rated on a scale of 9 (firmest, tartest, or most prefered) to 1.
Mean separation for each factor by Duncan's multiple range test, 5% level.

Table 3. Respiration, firmness, and acidity of 'Stayman' apples after storage for 9 months at 0°C[z]

Storage regime (months) CA	Air	Respiration[y] (mg CO_2/kg-hr)	Firmness[x] (kg)	Acidity[x] (mg/100 ml)
9	0	11.4 c	5.8 a	372 a
7	2	15.5 b	5.5 ab	386 a
5	4	16.8 ab	5.2 abc	372 a
3	6	17.9 ab	4.8 bc	334 b
0	9	19.4 a	4.6 c	304 b

[z]Mean separation for each factor by Duncan's multiple range test, 5% level.
[y]Respiration in air at 18.3°.
[x]After storage plus 1 week in air at 18.3°.

Table 4. Taste panel evaluations of 'Stayman' apples after storage for 9 months at 0°C plus 1 week in air at 18.3°C.

Storage regime (months) CA	Air	Ratings[z] Firmness	Tartness	Preference
9	0	5.7 a	5.4 ab	5.7 a
7	2	5.0 b	5.8 a	5.0 ab
5	4	4.6 bc	4.8 bc	4.9 ab
3	6	4.2 c	4.3 cd	4.4 b
0	9	3.2 d	3.6 d	3.1 c

[z]Rated on scal of 9 (firmest, tartest, or most preferred) to 1. Mean separation for each factor by Duncan's multiple range test, 5% level.

CA storage. The shift also gradually decreased firmness, but acidity was higher in apples that were held at least 5 months in CA before shifting to air storage (Table 3). Further, ratings for firmness, tartness and preference increased as the proportion of the storage period the apples had been in CA storage increased (Table 4).

The foregoing results indicate that the benefits derived from CA storage of 'Stayman' apples decreased proportionally as the proportion of time in CA storage decreased, even though subsequent storage in air was at 0°C. To assure the trade and consumer of high quality 'Stayman' apples all of the fruit from a given CA room should be marketed before additional CA rooms are opened.

Literature Cited

1. Anderson, R. E. 1967. Experimental storage of Eastern-grown 'Delicious' apples in various controlled atmospheres. *Proc. Amer. Soc. Hort. Sci.* 91:[illegible]
2. ———, C. S. Parsons, and W. L. [illegible] Jr. 1969. Controlled atmosphere storage of Eastern-grown peaches and nectarines. U.S. Dept. Agr. Mktg. Res. Rpt. [illegible] p.
3. Blanpied, G. D., and D. H. Dewey. [illegible] Quality and condition changes in McIntosh apples stored in controlled atmospheres. *Mich. State Quart.* [illegible] 42:771-778.
4. Fidler, J. C., and C. J. North. 1967. The effect of conditions of storage on the respiration of apples II. The effect on the relationship between loss of respiratory substrate and the formation of CO2 products. *J. Hort. Sci.* 42:207-221.
5. Knee, M. 1971. Ripening of apples during storage. III. Changes in the chemical composition of Golden Delicious apples during the climacteric and under conditions simulating commercial storage practice. *J. Sci. Food Agr.* 22:371-[illegible]
6. Okamoto, T. 1961. Biochemical studies on apples in storage. III. Metabolism of malic acid (in Japanese). *J. Agr. Chem. Soc. Japan* 35:1355-1360. (*Chem. Abs.* 57:3840g 1962.)
7. Scott, K. J., E. G. Hall, T. J. Riley, and D. E. Finlay. 1962. Quality of diphenylamine treated Granny Smith apples in relation to the composition of the storage atmosphere. *Austral. J. Exp. Agr. & Animal Husb.* 2(6):153-159.
8. Smock, R. M. 1942. Influence of controlled atmosphere storage on respiration of McIntosh apples. *Bot. Gaz.* 104:178-184.
9. ———. 1958. Controlled-atmosphere storage of apples. *N.Y. Agr. Col. (Cornell) Ext. Bul.* 759.

Viability of Apple Blossom Buds after Test Freezing[1]

Paul Chen and P. H. Li[2]
University of Minnesota, St. Paul

Abstract. **The viability of apple blossom buds after test freezing was quantitatively estimated by the technique of electrical conductivity combined with visual observation. A sharp increase in the percent of leaching always indicated freezing injury to the blossom. This technique can provide not only a quantitative estimation of freezing injury but it can detect small differences in the cold tolerance existing between species.**

Due to their physiological state, apple flower buds are rarely killed by the low temp of mid-winter. However, shortly before, during and after blooming only a few degrees below freezing can cause considerable damage to the blossom buds. In this communication, we would like to report the precise freezing injury of apple blossom buds as evaluated by the technique of electrical conductivity.

Three *Malus* species: *Malus tschonoeski*, Maxim., *Malus sieboldi arborescens*, Reg., and *Malus sylvestris* Mill. cv. Haralson were used for this study. Excised blossom buds at the full pink stage (Fig. 1A) were subjected to controlled freezing tests. Electrical conductivity based on the leaching of electrolytes from injured cells after exposure to a freezing temp was used to evaluate the viability (2). Before collecting leachate after freezing, the viability of each bud was evaluated visually by examining its oxidative browning associated with injury.

Four blossom buds were placed

[1]Received for publication May 9, 1973. Scientific Journal Series paper number 8321, of the Minnesota Agricultural Experiment Station. This research was support in part by a grant from the Hill Family Foundation.

[2]Laboratory of Plant Hardiness, Department of Horticultural Science.