Table 2. Percent decay on peaches selected at various sampling points in a commercial packing line and held for 7 days at 1°C plus 3 days at 21°.

Sampling point in packing shed (in sequential order)	% decay[z] on indicated cultivars and sampling dates (1974)									
	Springold	Redcap	Coronet			Dixiland				
	Je 3	Je 4	Je 6	Je 14	Je 21	Je 26	Jy 12	Jy 17	Jy 19	Avg[y]
Bulk bin	49	46	27	24	15	6	19	17	21	24.9 b
Dump tank	77	54	40	53	29	26	25	27	26	39.7 bc
Washer	54	53	42	53	29	13	48	57	52	44.5 c
Waxer	7	7	12	7	2	1	7	7	10	6.7 a
Hydrocooler	11	7	16	6	0	0	11	10	12	8.1 a
Hydrocooler (by-passed waxer)	50	51	40	21	30	33	40	46	43	39.3 bc

[z]Brown rot, rhizopus rot, and miscellaneous decay on 9 to 10 kg samples.

[y]Mean separation in columns by Duncan's multiple range test, 5% level.

levels of fungicide residues.

The average weight loss of waxed peaches after a simulated marketing period was 6.5%, compared to 9.4% for washed fruit and 9.7% for unwaxed (but hydrocooled) peaches. Weight loss of waxed, hydrocooled peaches was 6.7 to 7.3% – again, not significantly different from that of the waxed but nonhydrocooled peaches.

As demonstrated under commercial conditions, decay and weight loss were controlled even when 5000 ppm Botran and 2500 ppm benomyl incorporated into a nonemulsified wax were applied after hydrocooling. Loss of some fungicide and presumably, of wax coating did occur, but the loss was statistically not significant and did not reduce the effectiveness of the wax treatment. We have shown that shippers with hydrocoolers at the end of the packing-lines can safely install a suitable waxer without costly alterations to the packing-line configuration and thus benefit from both postharvest treatments.

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The Effect of Covering Apples during Development[1]

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Abstract. **Covering apples with foil bags about 1 month after bloom to harvest had no effect on fruit size or starch content, had inconsistent effects on fruit firmness, and reduced soluble solids, anthocyanin and chlorophyll. Uncovering fruits at various times before harvest allowed formation of anthocyanin, maximum amounts being dependent on cultivar and time of exposure.**

Recent reports describe the Japanese practise of covering apples during development (2, 6). Initially the technique was used to prevent fruit injury by insects and diseases but now its main purpose is to obtain fruit with a smooth finish and often uncharacteristic but desirable color (2).

This paper describes experiments in which fruit of 3 North American apple cultivar and the Japanese cultivar 'Mutsu' were covered during development with aluminum foil bags. Attendant changes in some fruit characteristics, particularly pigments, are presented.

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Fruit from the periphery of 11 to 13-year-old trees of 'Mutsu', 'McIntosh', 'Delicious' strain Vance, and 'Golden Delicious' on 3 rootstocks Malling (M) 2, Malling Merton (MM) 106, and MM 111 were used.

Bags of aluminum foil, brown paper, and black cloth were compared for their suitability for apple covering. Spot measurements of temperature with matched thermistors showed that when air temp (shaded but non-aspirated) was 22°C, temp in foil bags were 1° higher, in brown bags 3° higher, and in black bags 12° higher. Severe scalding of apples in black bags was observed when maximum temp (screened and aspirated) reached 28°.

Light transmission of bags was compared using an Eppley precision pyranometer uniformly sensitive to all wavelengths from 285 to 2800 nm. Brown bags allowed 41% of the incident global radiation through while black bags allowed 19% and foil bags 15%. Brown paper bags did not withstand weathering and had to be replaced. From the foregoing it was decided that aluminum foil bags were most suitable.

Apples were covered with foil bags on June 26 about 1 month after full bloom. Enough were covered to allow for 6 to 10 fruits in each sample in each experiment. The bag was placed over the fruit, gathered and tied with a plastic tie around the pedicel. Apples with long pedicels e.g. 'Delicious' and 'Golden Delicious' were easy to cover while others with short pedicels e.g. 'McIntosh' were difficult. Because the bags were large, allowed fruit expansion and withstood weathering, they did not have to be replaced. About 5% of the bags were lost to air blasts from spray machinery. Another 2% of the bags split during fruit development especially with the larger fruited cultivars. The resultant exposed part of the apple rapidly turned red. These samples were discarded.

Anthocyanin and chlorophyll content of the apple skin were measured by previously discussed methods (1, 4, 5). Fruit size was measured with a Cranston fruit thinning gauge, soluble solids with a Toshiba hand refractometer and fruit firmness of the pared flesh with an Effegi fruit tester fitted with the 1.12 cm (7/16 inch) tip. Starch content was judged by applying a solution of iodine in aqueous potassium iodide to a traverse equatorial section and relating the

Table 1. Characteristics at harvest of fruit of 4 apple cultivars which were left exposed or were covered from about one month after bloom[z].

Cultivar	Diameter (cm)	Starch index[y]	Firmness (kg)	Soluble solids (%)	Anthocyanin (nmoles/cm^2)	Chlorophyll A_{650}-A_{620}/ (cm^2/ml X 10^{-4})
McIntosh						
exposed	6.83	4.00	8.38	12.87	37.61	39.7
covered	7.04	3.66	8.05	12.00	0.26a	17.9a
Delicious						
exposed	6.94	3.00	8.59	14.19	65.59	3.1
covered	6.78	3.00	9.16	13.42a	3.96a	5.1b
Golden Delicious						
exposed	7.06	8.25	6.85	17.44	2.28	27.0
covered	7.01	7.90	7.77a	14.62a	0.65a	10.8a
Mutsu						
exposed	8.38	8.30	7.98	15.23	3.41	51.9
covered	8.19	7.70	7.98	12.39a	0.19a	11.3a

[z]Paired means are different at 1% (a) and 5% (b) in t test.

[y]Rating of 1 (high starch content) to 9 (low starch content).

color to previously prepared standards (3).

Covering did not influence fruit size or starch content, had inconsistent effects on fruit firmness, but reduced soluble solids, anthocyanin and chlorophyll levels (Table 1). Covered fruit did not taste as sweet as those exposed and lacked characteristic flavor. Soluble solids differences were small except for 'Golden Delicious'.

Anthocyanin. Maximum anthocyanin synthesis was obtained in the 'Delicious' and 'McIntosh' (Fig. 1). The anthocyanin content of 'Delicious' apples initially covered but exposed before harvest was not greater than those which had never been covered. In contrast, fruit of the other three cultivars, especially 'McIntosh', formed more anthocyanin if covered and then exposed 20 to 30 days before harvest than if continually exposed. This suggests an optimum time for bag removal to obatin maximum red color formation. This may be coincident with a certain stage in fruit growth and development, possibly the time of the pre-climacteric minimum respiration rate and the onset of the ripening phase. In this particular season it was observed that the onset of rapid red color formation in 'McIntosh' was about 20 days before harvest.

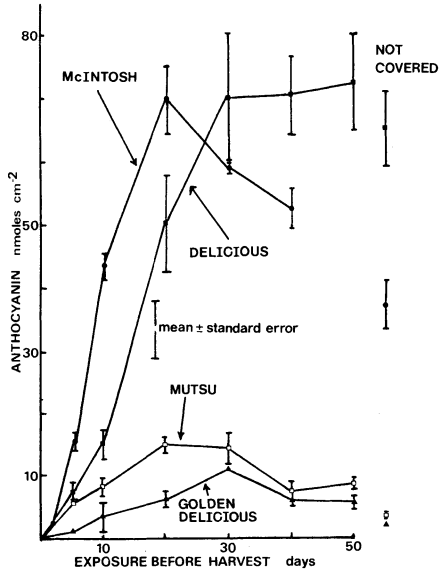

Fig. 1. Anthocyanin content at harvest of 4 apple cultivars which had been covered with foil bags about one month after bloom and uncovered at various times before harvest, or were not covered (extreme right).

This technique of covering fruit and then exposing them to obtain enhancement of red color gave superior results, in absolute terms, to the previous technique of stimulation with supplementary light (4, 5). For instance 'Mutsu' did not respond consistently to supplementary light (5), while in the present study 15.02 nmoles of anthocyanin were obtained in the 20-day exposed compared to 3.41 nmoles in those not covered.

Previous work has shown a light dependent lag or induction period in the appearance of anthocyanin in apple. Siegelman and Hendriks (7) reported a 20-hr lag period in detached apple skin. Proctor and Creasy (4) reported a 12 to 15-hr lag period in attached 'McIntosh' apples. One day was required for stimulation of anthocyanin synthesis from an existing very low base level after bag removal in both 'McIntosh' and 'Delicious'. At this latitude (42°51'N) in early Sept. this would be about 13 hr daylight and is in agreement with earlier findings mentioned above (4, 7).

Chlorophyll. With the exception of 'Delicious', apples which were covered had less chlorophyll than those which were exposed (Table 1) in spite of the known decrease during the season in the latter (1). Excluding light from developing apples probably initially promoted degradation of existing chlorophyll, and subsequently inhibited formation.

Exposing covered apples of 'McIntosh', 'Golden Delicious', 'Mutsu' and 'Delicious' induced chlorophyll synthesis in all except the latter but only in fruit exposed for 30 to 40 days. Fruit exposed for less time had a unique pink, or red color when compared with exposed fruit. This was probably due to the high anthocyanin to chlorophyll ratio.

Storage. After 2 months storage at approx 0.5°C and 95% relative humidity 'McIntosh' apples which had been covered still lacked characteristic flavor, had lower soluble solids and the flesh appeared whiter than control apples. After 4 months storage the influence of covering on both external and internal color was still apparent and in addition there was more stem rot and brown core in apples that had been covered. However, the incidence of disease was low and the stored fruit had good keeping quality. Mink (2) reported poor keeping quality of covered fruit. We stored fruit that was not exposed before harvest while that to which Mink (2) referred was probably exposed prior to harvest. This may increase the possibility of storage breakdown. 'Delicious' apples that had been covered and stored were very similar to exposed fruit except that the flesh was whiter and they had less soluble solids.

The Japanese have used the technique of covering apples to produce a unique fruit which commands a high price in specialty markets. It is doubtful that North American growers would be interested in this technique from this standpoint. However others may find a use for it. The home gardener could cover his fruit to reduce or eliminate the use of pesticides usually found necessary to attain quality fruit. If red fruit is desired the fruit can be uncovered prior to harvest. However, this may increase the possibility of storage disorder to some extent (2). Scientists could use this technique for studying formation of apple pigments, skin disorders such as russetting of 'Golden Delicious', and the relationship of light to the development of constituents which affect aroma, flavor and texture.

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