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Short Communication

Flow of Chromium into Apple Fruit during Development[1]

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ABSTRACT

A continuous flow of chromium into apples occurs throughout their growth. This ready movement of chromium into the apple is similar to that reported for essential trace elements such as boron, zinc, iron, copper, and manganese but differs from the restricted movement reported for mercury and cadmium.

The sodium salt of 4, 6-dinitro-*o*-cresol is widely used as a blossom thinner for Golden Delicious apples in the Pacific northwest. The commercial formulation of this compound, Elgetol, contains 1.9% sodium bichromate. For continued clearance of the use of Elgetol as a thinner, the Environmental Protection Agency required information on the chromium residue in apples from trees treated at the time of bloom. While obtaining this information, we found that there is a continuous flow of chromium into Golden Delicious apples throughout their development, irrespective of Elgetol treatment. Although several trace elements are known to move readily into apples during growth, we are not aware of any previous description of the flow of chromium and so record our observations here.

MATERIALS AND METHODS

Four Golden Delicious apple trees in each of two orchards in the Wenatchee, Washington area were sprayed to run-off with 1.67 ml of Elgetol/1 H_2O. This solution contains about 13 μg/ml chromium. A single application was made to each tree on May 5 or 6, 1972 during full bloom. Both treated and control trees had been sprayed with Elgetol in previous years.

Sixteen samples (one each from the eight treated trees and from eight untreated trees) were collected on each of the following dates: May 19, June 2, August 4, and September 15. This was about 2, 4, 13, and 19 weeks after treatment. The last sampling was at the normal time for harvest. One hundred apples were collected from each tree at the first sampling, 50 from each tree at the second sampling, and 10 from each tree at the third and fourth samplings.

The samples of May 19 were analyzed in their entirety. Apples were taken at random from the June 2 samples to give subsamples weighing about 75 g. Apples in the samples of August 4 and September 15 were sliced and about one-eighth of each was composited into a single sample for analysis.

Subsamples were dried 24 to 48 hr in a forced convection oven at 65 C. Peel and seeds were not removed. Dried subsamples were ashed at 625 C for 5 to 16 hr in porcelain crucibles. The light grey ash was dissolved in sufficient 10% HNO_3 to give a pH below 1 (5–10 ml depending on the sample), made to volume with deionized water, and centrifuged.

Chromium in the samples was measured on a Varian-Techron AA-120 atomic absorption spectrometer at 357.9 nm. Recovery of chromium added to samples averaged 96%.

Table I. *Chromium Concentration of Apples During Growth*

Values listed represent the averages of four samples. Almost all samples were within 10% of the mean except for the earliest samples collected which showed somewhat greater variation. A single treatment (dilute Elgetol spray containing 13 μg/ml chromium) was applied at bloom. The last sampling was at normal harvest time.

	Time after Bloom	Avg Fresh Wt per Apple	Cr Concn
	weeks	*g*	*µg/g*
Wenatchee Tree Fruit Research Center			
Control	2	0.644	0.119
	4	4.64	0.044
	13	95.3	0.022
	19	162.4	0.018
Treated	2	0.747	0.354
	4	4.55	0.068
	13	98.4	0.022
	19	158.9	0.020
Columbia View Experimental Plots			
Control	2	0.815	0.139
	4	4.85	0.046
	13	79.9	0.024
	19	156.8	0.017
Treated	2	0.788	0.335
	4	4.59	0.084
	13	112.8	0.023
	19	183.4	0.017

RESULTS AND DISCUSSION

Two weeks after treatment, the young apples from trees sprayed with Elgetol contained significantly more chromium than those from untreated trees—over 0.3 μg/g *versus* slightly over 0.1 μg/g fresh weight. During the next 17 weeks (from 2 weeks after bloom until harvest), the apples increased in weight about 200-fold, and chromium concentrations dropped

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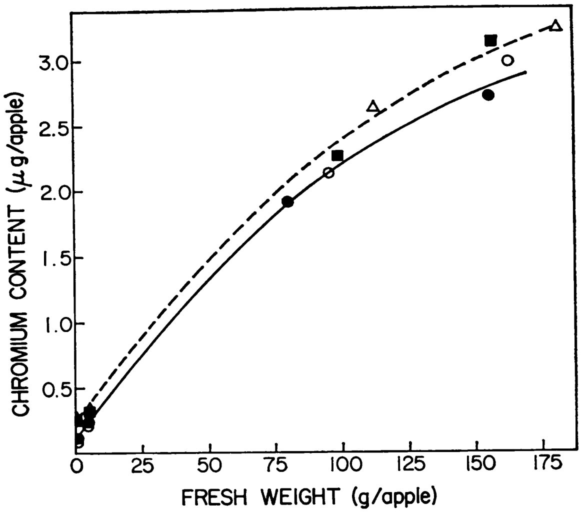

FIG. 1. Flow of chromium into apple fruits during growth. Each point represents the average of four samples. Apples from untreated trees grown at Wenatchee Tree Fruit Research Center (○); at Columbia View Experimental Plots (●). Apples from treated trees receiving a single spray of Elgetol containing 13 μg/ml chromium at bloom, grown at Wenatchee (■); grown at Columbia View (△). The first samples were collected 2 weeks after treatment and the last at normal harvest.

about 18-fold in treated and 7-fold in untreated apples. At harvest, very little difference in concentration remained (Table I).

In spite of the drop in concentration there was a sizable movement of chromium into apples during development, as shown in Figure 1. The amount of chromium per apple increased 25- to 39-fold on untreated trees and 12-fold on treated trees, to a level of almost 3 μg per apple at harvest in both cases. The source of the chromium measured in this study is not known. It might have been retained in the trees or the soil from previous Elgetol treatments. Naturally occurring chromium in the soil appears a more likely source, however, since the total chromium content of most soils is in the range of 5 to 1000 μg/g (4), and an Elgetol application should add less than 3 ng/g of chromium to the top meter of soil.

The chromium flow appears to be a normal physiological phenomenon associated with fruit development. Chromium has long been known to be a trace constituent of apples (7). We have measured chromium concentrations in locally purchased Golden Delicious apples ranging from 0.02 to 0.08 μg/g. Similar concentrations have been reported in studies using neutron activation (2) and colorimetric (9) analysis as a means of chromium detection. Essential trace elements commonly encountered in biological systems move readily into the apple during its growth in a manner analogous to that of chromium. These include boron (3, 5), and iron, manganese, zinc, and copper (1). In contrast to these common micronutrients and to chromium, two other metals, mercury and cadmium, which are not usually considered as normal plant constituents, showed quite different patterns of movement. Mercury sprayed on trees exhibited little movement into developing apples until they were more than half-grown, and then the mercury content only increased 2- to 3-fold by harvest (8). Cadmium also showed a similar pattern of restricted movement (6).

Preliminary experiments suggest that at least 40% of the chromium in mature apples is not readily extracted by water. Extraction with 50% ethanol removes even less chromium (9). Further work on the origin of chromium in apples will be with Golden Delicious and other varieties both from treated plots and from plots which have never been sprayed with chromium-containing solutions.

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