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Effects of Water Quality on Canned Carrots, Sweet Cherries, and Apricots[1]

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Abstract. The chelating agents, monocalcium disodium salt of ethylenediaminetetraacetic acid ($CaNa_2EDTA$) and sodium hexametaphosphate (Na-HMP), at 800 ppm, were used for canning 'Honey Sweet' carrots, 'Van' sweet cherries, and 'Large Early Montgament' apricots with water containing 0, 20, 40, 80, and 160 ppm of Ca and 20 ppm of magnesium. The control cans did not contain EDTA or Na-HMP.

The canned carrots, cherries, and apricots were stored at 70° or $100^{\circ}F$. Evaluations were made at 60-day intervals for 6 months. All 3 commodities had better organoleptic[4] acceptibility when they were canned with $CaNa_2$ EDTA or Na-HMP than the controls.

Carrots canned with $CaNa_2EDTA$ were firmer and retained better color than those canned with Na-HMP or the controls. The rate of loss of firmness and color increased with time of storage. Retention of firmness, volatile reducing substances, pH, and taste quality was improved in sweet cherries and apricots canned with $CaNa_2EDTA$ or Na-HMP.

The salts present in water used for canning fruits and vegetables affect the quality of the processed product. Firmness was retained better in beans (8), apples, pears, apricots, peaches (9), and tomatoes (10) when hard water containing Ca or magnesium was used for canning. Calcium salts have been used for canning tomatoes (11), green and red sweet bell peppers (6), and cauliflower and blanched apple slices (7). Kertesz (11) suggested that polygalacturonic acid or demethoxylated pectin combines with Ca and other elements to produce Ca pectate. These compounds lend additional firmness to the tissues, consequently, a better preservation of the original texture.

While the presence of some salt in water improves the quality of canned fruits and vegetables, an excess or even inclusion of other salts may cause harmful effects (12, 18).

Natural and industrial pollutants can make culinary water supplies unfit for food processing. Water in Utah and throughout much of the West contains substantial amounts of calcium, magnesium, iron, copper, sulfur and other minerals. Sulfur compounds in water can cause detinning and consequently corrosion of the cans. They precipitate due to polymerization and can cause scum and cloudiness in brine or syrup. Iron and copper compounds combine with tannins in fruits and can cause blackening. Sodium, calcium, and magnesium sulfates give bitter flavors to the processed fruits and vegetables. The calcium and magnesium chlorides cause hardness of water. All of these constituents will affect flavor quality of the processed products. Impurities cause processing problems and considerable economic loss, consequently, processors pay heavy penalties for using hard and raw water for food processing and consumers receive inferior quality products. To meet U. S. Public Health Standards, processing water can be softened by using either water softeners or ion-exchange resins. Home canners as well as commercial canners can benefit by using chemical water softeners.

Quality of fruits and vegetables canned in hard water may be improved by adding chelating agents to the canning water. These compounds sequester the trace metals that catalyze oxidative breakdown of food and thus can improve flavor, color, and texture of foods (19). They also prevent formation of insoluble metal salts which cause turbidity and other quality deterioration (2). One of the most commonly used chelating agents is ethylene diaminetetraacetic acid (EDTA). The chemistry, mechanism of action, and the role of EDTA in canning and food preservation have been well documented (4). The other groups of compounds which have been used as water-softeners are the polyphosphates (16, 18), Ca phytate (10), thiourea (3), and citric acid (5).

In this study, 500 ppm of $CaNa_2$ EDTA and Na-HMP were used with water containing different concentrations of Ca for canning apricots, sweet cherries, and carrots to determine their effects on color, titratable acidity, pH, firmness, volatile reducing substances, and organoleptic quality during storage for 6 months at 70° or $100^{\circ}F$.

Material and Methods

Food grade $CaNa_2EDTA$, Na-HMP, anhydrous $CaCl_2$, and

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[4]Organoleptic is a synonym for 'sensory' when referring to examination by taste and smell by a panel of judges.

anhydrous $MgSO_4$ were obtained from Geigy Industrial Chemical Company, Ardsley, N. Y.; Calgon Corporation, Pittsburg, Pa.; and Baker Chemical Company, Phillipsburg, N. J., respectively.

Calcium, 0, 20, 40, 80, or 160 ppm was added to the distilled and demineralized water before used for canning. At each level, except for 0 ppm of hardness, 20 ppm of Mg was also included. The calculation was based upon the net fluid content per can.

Sweet cherries (cv. Van) and apricots (cv. Large Early Montgament) were harvested at their optimal maturities based on visual appearance for canning. Carrots (cv. Honey Sweet) were obtained from a local supermarket and cut into 1/4- and 3/8-inch-slices before canning.

In 401 x 211 size cans (of appropriate enamels), the fruits of sweet cherries and apricots were canned with 40% sugar syrup containing 500 ppm of $CaNa_2EDTA$ or Na-HMP and 800 ppm of $CaNa_2EDTA$ or Na-HMP were used along with 2% NaCl for carrots.

The control cans did not contain $CaNa_2EDTA$ or Na-HMP. The canned fruits and carrots were stored for six months at 70°F and 100°F. At each 60-day interval, the samples were evaluated for the following quality attributes: firmness, color, titratable acidity and pH, volatile reducing substances (VRS), and organoleptic acceptibility.

The firmness in carrots and apricots was determined with the Chatillon gauge-r 516-500; John Chatillon and Sons, Kew Gardens, N. Y., (a Magness pressure spring-type tester) 1/8 inches in diam (14); while for sweet cherries the shear press of Bridge Food Machinery Company, Philadelphia, Pennsylvania was used.

The pigments in sweet cherries (anthocyanins) and carrots (carotenoids) were determined colorimetrically (1, 20). The color in apricots was measured with a Hunter Color and Color-Difference Meter. This instrument has 3 photocells which are so filtered as to measure lightness (L), redness (aL), and yellowness (bL). The readings of the yellow standard color plate were L-54, aL-1, and bL-32.

To determine titratable acidity, 25 g of fruit was homogenized, diluted to 250 ml with distilled water, and titrated to pH 8.1 with 0.1 N sodium hydroxide. pH readings were made on blended and diluted (25 g per 100 ml) samples (17). Volatile reducing substances of the fruit were determined by the potassium permagnate oxidation method of Luh et al. (13). The quality of the processed products was evaluated by a trained panel using a 9-point Hedonic scale (15).

Each value in figures and also in Table 1 represents the mean value of 3 replicates. Triplicate determinations of each of 3 replicates were made for each date of sampling. Analysis of variance with a completely randomized technique was used to analyze the data. In the text, reference to "significance" denotes a significant difference at the 0.05 level.

Results

Carrots. Carrots canned with $CaNa_2EDTA$ lost firmness at a significantly lower rate than those canned with Na-HMP or the controls. There was a consistent loss in firmness of the samples which were stored at 100°F; while in the samples held at 70°F, the firmness decreased slowly up to the 4th month and thereafter rapidly (Fig. 1, a,b).

A decrease in firmness was accompanied by a loss of color in samples at both 70°F and 100°F; however, the samples canned with $CaNa_2EDTA$ retained significantly more color than Na-HMP (Fig. 1, c,d).

Sweet cherries and apricots. After 6 months of storage, sweet

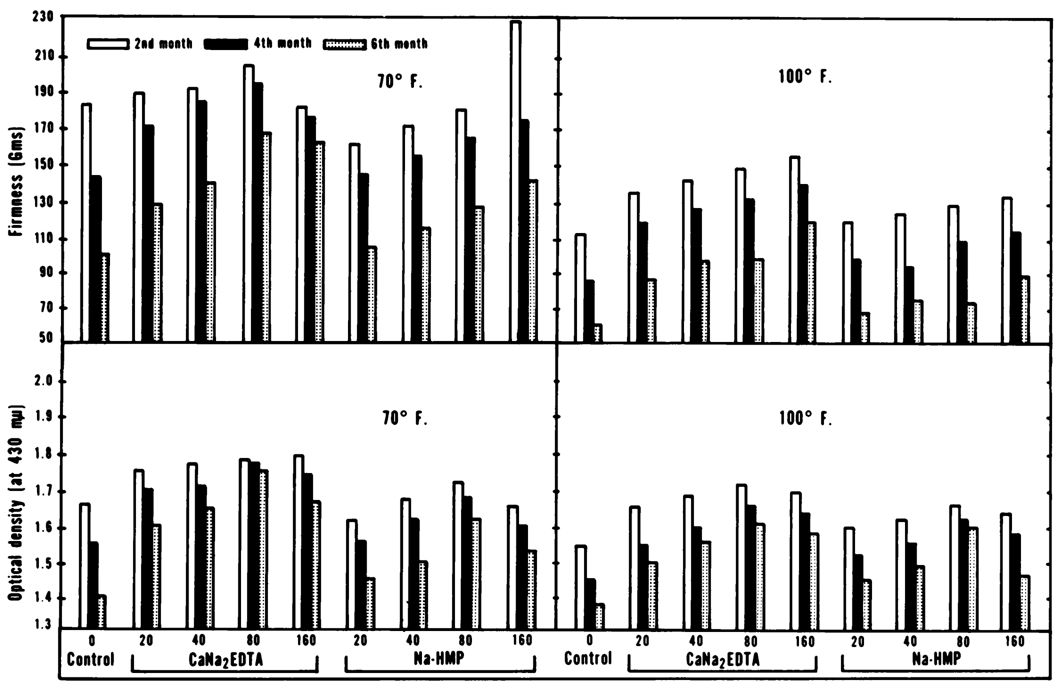

Fig. 1. Effect of $CaNa_2EDTA$ and Na-HMP to water of different hardness and firmness and color of processed carrots stored at 70° and 100°F.

Table 1. Effect of $CaNa_2EDTA$ (500 ppm) and Na-HMP (500 ppm) at different water hardness on organoleptic quality evaluation of canned sweet cherries after a 6-month storage period at 70°F.

Quality	Control					$CaNa_2EDTA$ (500 ppm)					Na-HMP (500 ppm)				
	0*	20*	40*	80*	160*	0*	20*	40*	80*	160*	0*	20*	40*	80*	160*
Texture	4.2	6.2	7.0	5.0	3.3	7.0	7.2	9.0	8.2	7.2	6.0	7.0	8.5	8.0	8.0
Flavor	4.0	4.5	5.1	5.3	3.5	7.2	8.0	8.5	8.0	6.8	6.5	6.5	8.0	8.0	7.5
Color	4.5	5.0	5.3	5.2	3.0	7.0	7.5	9.0	8.2	6.5	7.0	6.3	8.2	7.2	7.5

*Water hardness in ppm.

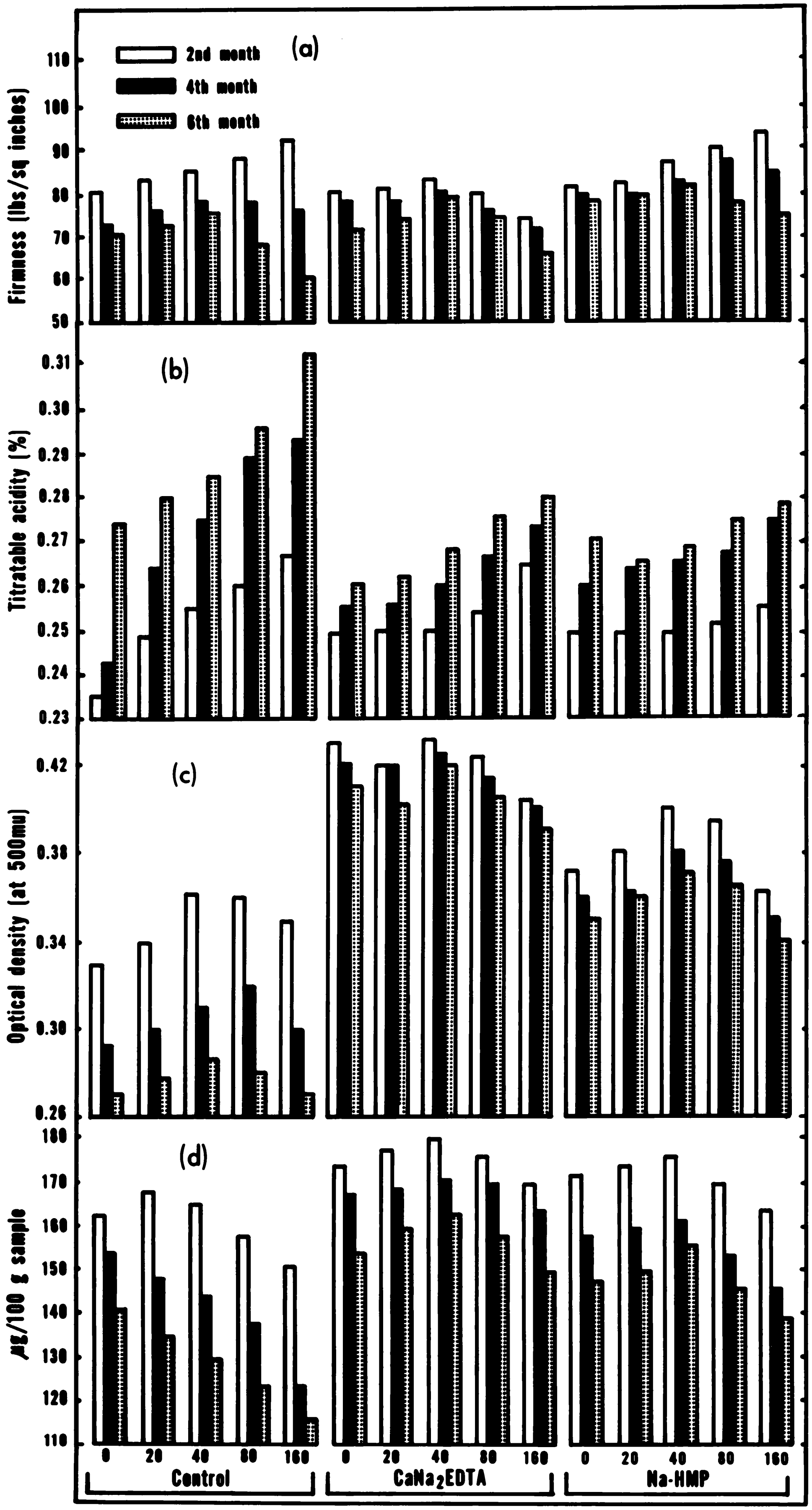

Fig. 2. Effect of $CaNa_2EDTA$ and Na-HMP to water of different hardness on firmness (a), titratable acidity (b), color (c), and volatile reducing substances (d) of sweet cherries.

cherries and apricots canned with 160 and 80 ppm retained less firmness than those canned with 40 ppm of water hardness (Figs. 2, 3). The retention of firmness, volatile reducing substances, pH, and sensory acceptibility was significantly higher in the samples canned with $CaNa_2EDTA$ or Na-HMP than the controls.

All 3 commodities had more organoleptic acceptibility when they were canned with $CaNa_2EDTA$ or Na–HMP than the controls (Table 1).

Discussion

Our data indicate that carrots, apricots, and sweet cherries canned with water containing 40 ppm of Ca with $CaNa_2EDTA$ had better texture, color, and sensory quality than those with 80 or 160 ppm. The higher concentration of Ca had adverse effects. It has been suggested that demethoxylation of natural pectin produces pectic acid which combines with Ca. This in turn results in a toughening of the plant tissue (11). Although pH determinations have not been made in the present

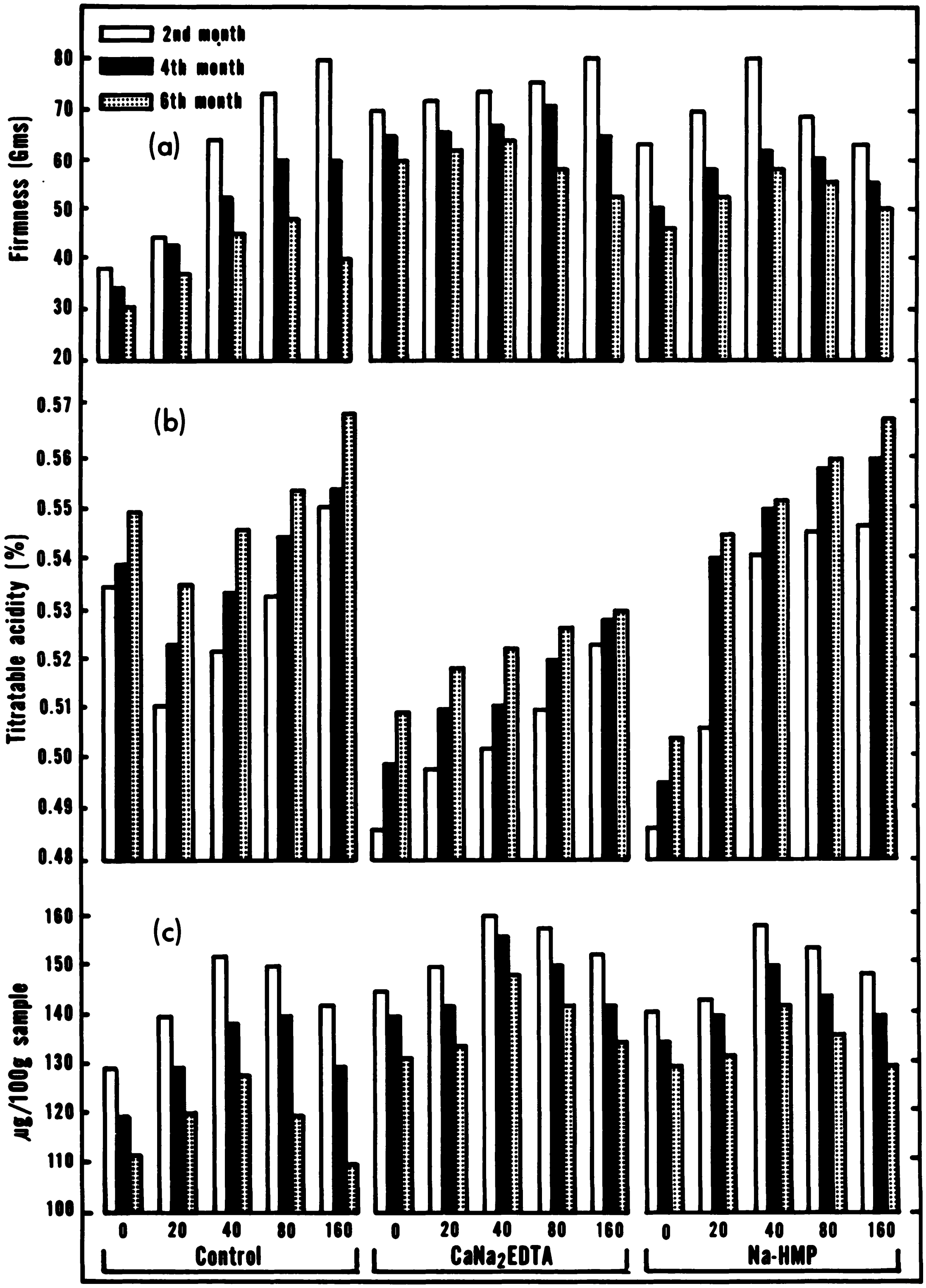

Fig. 3. Effect of $CaNa_2EDTA$ and Na-HMP to water of different hardness on firmness (a), titratable acidity (b), and volatile reducing substances (c) of apricots.

investigations, it is likely that an excess of Ca and Mg in the canning water causes hydrolysis of Ca compounds and thus produces H ions in the solution. The H ions cause decreases in pH, firmness, volatile reducing substances, color retention, and increases in titratable acidity and tin corrosion.

A striking increase in the rate of deterioration of pigments along with decrease in pH occurs in the samples canned with 80 and 160 ppm of Ca. However, in the samples canned with either $CaNa_2EDTA$ or Na-HMP, the rate of deterioration of pigments (anthocyanins and carotenoids) was not so pronounced as in the controls during the 6-month storage period. Therefore, in addition to their water-softening ability, EDTA and Na-HMP inhibit the degradation of pigments in canned cherries and apricots. Since the presence of Fe and Cu in canning water causes discoloration (10) of the processed products by oxidation of carotenoids or anthocyanins, it has been suggested that EDTA or Na–HMP prevent discoloration by chelation with these metals (5).

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Effects of Telone and Nemagon on Essential Nutritive Components and the Respiratory Rates of Carrot (*Daucus carota* L.) Roots and Sweet Corn (*Zea mays* L.) Seeds[1,2]

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Abstract. Soil fumigations with Telone (1,3-dichloropropene and other chlorinated hydrocarbons) at the rates of 10, 20, and 30 gal/A and Nemagon (1,2-dibromo-3-chloropropane) at the rates of 1, 2, and 3 gal/A, one week before planting carrot and sweet corn seeds brought about significant increases in the content of total carotenes, β-carotene, and total sugars in carrots and the total carotenoids in sweet corn seeds and decreases in respiratory rates of the carrot roots.

Virtually every crop has its complement of nematode parasites. More than 150 nematode species are being studied to determine their roles in plant disease. Certain plant-parasitic nematodes often are the principal limiting factors of the plant growth. Practical control of nematodes with chemicals is a recent development. The use of nematicides has developed rapidly from a few hundred lb. in 1943 to an annual total exceeding 60 million lb. in 1963 (12). The effective nematicides in use today are volatile halogenated hydrocarbons. They have high vapor pressure that spreads between the soil particles. In addition, because of their volatile nature, they cause a negligible residue problem. It has been reported, however, that the use of brominated hydrocarbon nematicides may result in significant increases in bromide residues (9, 15, 18), depending on dosage rate, soil type, available moisture, etc. Telone[4] (1,3-dichloropropene and other chlorinated hydrocarbons) and Nemagon[5] (1,2-dibromo-3-chloropropane) are nematicides commonly used for the control of root knot nematodes, lesion or meadow nematodes, cyst formers such as sugar beet nematodes, and many other species. A previous study showed that preplanting soil fumigation with Telone (10, 20, and 30 gal/acre) and Nemagon (1, 2, and 3 gal actual/acre) increased total carotene, β-carotene, total sugars and decreased the respiratory rates in carrot roots (20). The mechanism(s) of this phenomenon is still unknown.

This paper presents the results of a second year's experiment on carrots and 2 years' studies on the effects of soil fumigants on the composition of sweet corn.

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[3]Department of Food Science.

[4]A product of Dow Chemical Company, San Francisco, Cal., contained 90 to 95% active ingredients.

[5]A product of the Shell Chemical Corporation, New York, N. Y., contained 67.2% active ingredients.