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Fluoride Content in Home-Canned Fruits in Utah

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FLUORIDE CONTENT IN HOME-CANNED FRUITS IN UTAH

by

Sydney Ann McDonald

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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Sydney Ann McDonald

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ABSTRACT

Fluoride Content in Home-Canned Fruits in Utah

by

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Utah State University, 1987

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The purpose of this research was to determine whether or not canning fruit using fluoridated water made a difference in the fluoride contents of the juice and the pulp. Four cities in Utah were chosen. Two cities were fluoridated (Brigham City and Helper) and two cities were not fluoridated (North Ogden and Price). Three homes were chosen within each city, and three jars of canned fruit (one jar each of apricots, cherries, and peaches) were selected from each home. The fruit samples were freeze-dried, and then the fluoride was measured with a fluoride ion electrode. A difference was found in the fluoride level of the juice and the pulp when canning using fluoridated water. However, this difference was not statistically significant and did not greatly contribute to the overall dietary fluoride intake.

(65 pages)

CHAPTER I

INTRODUCTION

The purpose of this research was to determine whether or not canning fruits using fluoridated water affects the fluoride content of the pulp or juice.

The Surgeon General of the United States officially stated that dental caries prevention and safety factors of controlled water fluoridation place it among the most conclusively proven public health benefits known (Menaker, 1980). This statement was made in 1956, and since then five consecutive presidents of the United States have officially endorsed this statement.

Fluoride usage increased during the decade of the 1960s to the 1970s. About 58% of the people in the United States have access to and use a public water supply. According to the United States Public Health Service, 86 million people in the United States consume fluoridated water, and another 9.5 million people consume water that is naturally fluoridated. Thus, almost 100 million people are partaking of the benefits of fluoridated water, while 115 million Americans do not have fluoridated water. Furthermore, 150 million individuals in 30 countries throughout the world use fluoridated water (Marier, 1977a).

On the average, in uncontaminated areas, rainfall contains from 0-.02 ppm fluoride, whereas in more industrialized areas rainfall contains anywhere from .2-14 ppm. Rainwater contributes up to 170 g of fluoride per hectare annually if coal is burned. Rainfall throughout the world has been estimated to contribute 1.2 X 1 kg of fluoride per hectare per year (Marier, 1977a).

The fluoride from water, including naturally occurring fluoride and that contributed by industrial plants, flows into the sea. Because of this, rivers have an average of about .09-.2 ppm fluoride. Rivers have about one-tenth of the amount of fluoride as seawater (Marier, 1977a).

Fluorine: The Element

Fluoride is a member of the halogen family with an atomic weight of 18.998413, an atomic number of 9, and a valance of -1. Although fluoride is distributed in many minerals, it occurs primarily in fluorspar (CaF2) and cryolite (FNa2A1f6) (Weast, 1982).

Moisson in 1886 isolated this element after 74 years of continued effort. Present commercial production methods are based upon Moisson's original procedures (Weast, 1982).

Fluorine is a pale yellow corrosive gas which is highly reactive with organic and inorganic substances. "Fluorine closely mimics hydrogen with respect to steric requirements at enzyme receptor sites" (Filler, 1982, pp. 1-2). Due to its very high electronegativity, fluorine frequently alters electronic effects and, thereby, chemical reactivity. "The strength of the carbon-fluorine bond exceeds that of the carbon-hydrogen bond," (Filler, 1982, pp. 1-2) which increases the thermal and oxidative stability in organofluorine compounds. If fluorine were to replace hydrogen in organic compounds, an astronomical number of new fluorine compounds could be created.

Fluoride was not produced commercially until World War II. Large quantities were produced as a result of applications of nuclear energy and the atom bomb. The production of uranium requires fluorine in addition to over 100 flurochemicals used in industry, such as high-temperature plastics. Flurohydrocarbons are also used in air conditioning and refrigeration.

Cancer chemotherapy, antiflammatory agents, antiparasitic agents, and antibiotics have fluorine-containing medicinals. "Several important new techniques such as positron emission spectroscopy, and the application of x-ray contrast agents have been developed with the use of fluoridated substances" (Filler, 1982, p. 1). Elemental fluorine is being studied as a rocket propellant as it has exceptionally high specific impulse value.

Fluoride in the Soil

Fluoride is found in most soils. In alkaline soils, however, it is usually fixed as an insoluble calcium salt or, in the absence of calcium, as aluminum silicofluoride. Sodium salt will form as a result of extremely alkaline soils. A small amount, approximately .5-6%, is lost to runoff and leaching each year.

It is very difficult to correlate the amount of fluoride in the soil with the amount of fluoride in plants. Marier (1977a) cited that Israel (1974), in an attempt to demonstrate this, increased the soil concentration of fluoride to 120 ppm only to produce the same level of fluoride in alfalfa plant tissue (1 ppm) as when the alfalfa plant was exposed to as little as .007 ug/m of hydrogen fluoride. This study also stressed the fact that airborne fluoride does not affect the soil fluoride to make an impact upon the uptake in the plant (Marier, 1977a).

However, levels of nutrients can, in fact, alter the fluoride uptake by the plant. The data of Brennand, Leone, and Daines suggest that:

> . . . levels of nitrogen, calcium, and phosphorus affect the concentration of fluoride in the tomato roots and leaves when fluoride is supplied in gaseous form to the plant . . . fluoride uptake was greater in plants grown on a potassium deficient medium and was less in plants grown on calcium or magnesium deficient media. (Marier, 1977a, p. 110)

Fluoride in Plants

There are many variables which influence the fluoride content of a plant. For example, the plant species, the variety, and the stage of development all affect the fluoride content. The part of the plant, whether it be a leaf, the fruit, or the root, plays a role in the total fluoride content. The needles or leaves, their location on the plant, and the time of year also are significant factors. Finally, fluoride in the air must be taken into consideration (Marier, 1977a).

As was mentioned earlier, fluoride is not distributed equally in the plant; rather, more fluoride has been found in the chloroplasts than in the cell walls or in the mitochondria. The fluoride content of the leaf does not change, while the fluoride content of the "root" may migrate to the "shoot." Loss occurs primarily through twigs, roots, and leaves. A few plants are able to lose fluoride by "volatilization of organofluorides." Other plants may lose fluoride due to the leaching which occurs with frequent rainfall (Marier, 1977a).

Not all plants, however, are sensitive to fluorides:

> Gladiolus, apricot, and Douglas fir are examples of sensitive plants, whereas cherry, tomato, and wheat are resistant plants. Fruits can also be injured by fluoride exposure. The most common example of injury is the soft suture disease in peaches. Fruit yield can also be decreased by fluoride exposure. High fluoride concentrations can also inhibit germination of seeds and restrict growth, although at low concentrations fluoride may enhance growth linearly. (Marier, 1977a, p. 7)

Even after several months between spraying and harvesting, fruit tree leaves which had been sprayed contained considerable residue of fluoride. This fluoride residue can be removed from hard-surface fruits, such as the apple or the pear, by washing the fruit with dilute hydrochloric acid and water. It is much more difficult to remove the fluoride residue from soft-surface fruits such as the apricot, the plum, and the peach (National Research Council, 1971).

Fluoride in the Ecosystem

If fluoride accumulates in plants, modified growth, decreased reproduction, and reduced fitness of the plant may result. These effects on individual plants may aggregate and alter the ecosystem. The altered flora may, in turn, have an altered consequence on the fauna. Thus, indirect changes in the ecosystem can be made as fluoride transfers from plants through the ecosystem, possibly interfering with each level of biologic organization (National Research Council, 1971).

Fluoride Toxicity

A lethal dose of sodium fluoride for a 70-kg man would range between 5-10 gm, which corresponds to about 70-140 mg/kg. Symptoms include "abdominal pain, diarrhea and vomiting, excessive salivation, thirst, and perspiration, and painful spasms of the limbs" (National Research Council, 1971, p. 195).

Fluoride intoxication results in skeletal changes and in ossification of tendons and ligaments (Bention, 1984). The precise mechanism by which fluoride poisoning occurs is unknown. However, it appears as though acute fluoride poisoning acts by blocking the normal metabolism of cells through enzyme inhibition. Blood clotting and membrane permeability are affected, and the origin and transmission of nerve impulses cease, causing death. Fluoride replaces calcium, and the bones become soft and crumbly and are chalky white. Protrusions of new bone develop in abnormal places (Bention, 1984).

An overdose of fluoride in the water supply occurred in Maryland in 1979 when 35 ppm fluoride were accidently infiltrated in the city water system for two to four days. Eight patients in that city treated for hemodialysis became ill on those days with chest pains, vomiting, nausea, and violent diarrhea. One patient died. A nearby hospital which did use deionized water for dialysis had no complaints from patients. No other complaints were recorded throughout the city during the days on which the fluoride overdose occurred (Menaker, 1980; National Research Council, 1971). See Table 1.

Table 1. Effects of fluoride toxicity (National Research Council, 1971).

Effect	Time	Dose	Amount fl (ppm)
Death	Two to four hours	Single	2,000-5,000
Kidney injury	Months	Repeated	100
Thyroid injury	Months or years	Repeated	50
Body weight loss	Four or more years	Repeated	40
Crippling fluorosis	Ten to 20 years	Repeated	20-80 (mg/day)
Mottled enamel	First eight years of life	Repeated	2-8

Chronic fluoride exposure occurs from air pollution among workers in insecticide, aluminum-mining, and phosphate-fertilizer industries. Industrial toxication of fluoride has occurred when workers inhaled 20-80 mg of fluoride daily for 20 years, causing chronic crippling skeletal fluorosis. Industry's efforts and methods for controlling fluoride dust have minimized the effects of fluoride toxicity (Menaker, 1980; National Research Council, 1971).

Skeletal fluorosis has occurred in American Indians who have more than 20 ppm fluoride in their drinking water. Rats drinking water with 50 ppm fluoride have thyroid changes; 100 ppm produce growth retardation, and 125 ppm result in kidney changes (Taves, Olsen, and Johansen, 1979).

Fluoride in the Diet

In the United States, fluoride intakes of humans from dietary sources are approximately .33-3.4 mg per day. Fluoridated water contributes an additional 1-1.6 mg per day (assuming an intake of 1.6 l/day). The air contributes a negligible amount of fluoride. Thus, if a person's water supply provides 1-2 mg/liter, his total daily fluoride intake can be estimated at .33 mg plus 1-2 mg = 1.2-2.2 mg. Meats are generally low in fluoride (< 2 ppm), although fish may be higher depending on whether or not the bones have been included (sardines with bones contain 40 ppm fluoride). Fruits are generally low in fluoride (< 1 ppm), and cereals and vegetables provide less than 3 ppm. Unless the water has been fluoridated, most beverages (with the exception of tea and some wines) do not contribute much fluoride. Milk usually contains about .1 ppm fluoride, whereas Coca-Cola and orange juice contain very little. The fluoride from beverages primarily reflects the fluoride in the processing or preparation of the product. Thus, unless a diet provides seafoods or tea, the fluoride level will be low (National Research Council, 1971). See Tables 2 and 3.

Table 2. Fluoride concentration in food groups (McClure, 1970).

Food group	Fresh (ppm)	Dry (ppm)
Meat	.01- 7.70	3.80- 7.7
Fish	.01-24.00	.00-84.5
Citrus fruits	.04- .36	1.40- 2.2
Noncitrus fruits	.02- 1.32	.45-12.0
Cereal and products	.10- 3.00	.00-28.3

Fluoride Analysis

The National Interim Primary Drinking Water Regulations (NIPDWR) issued prescribed procedures for determining methods for chemical analysis of water and wastes in addition to standard methods for examining water. Amendments to these regulations were updated on August 27, 1980, and in March 1986. These regulations set the standards of acceptance in addition to the sensitivity, precision, and accuracy of five different methods for determining fluoride content in water. The agency has found that laboratory procedures for the determination of fluoride are successful for concentrations from 1-10 mg/l to within plus or minus 10% of the true value. The EPA has determined the cost for determining fluoride by each of the following methods to be approximately $10.00 for an analysis of a single sample (United States Environmental Protection Agency, 1986).

Table 3. Fluoride concentrations in food (Marier, 1977a).

Plant	Part	fluoride concentration (ppm dry weight)
Carrots	Roots	.4-8.4
Onions		3.0
Beans		3.2
Tomato	Leaves	8.0
	Stem	2.0
	Fruit	2.0
Peach	Leaves	3.4
Corn	Cob	1.6
Wheat	Grain	1.0
Oats	Grain	.5
Potato	Tuber	1.5-3.0
Sugarbeet	Root	3.3-6.0
Cabbage	Edible part	1.5
Cauliflower	Flower	.9

The fluoride electrode is a sensitive ion sensor which contains a single crystal of lanthanum fluoride. This creates a potential when fluoride ions are present. A pH meter is used to determine the millivolt readings. The fluoride ion electrode is sensitive to the activity, not the concentration of fluoride ions, so that the fluoride activity and concentrations are constant when samples and standards are adjusted for their ionic strength. A buffer is added to prevent interference from hydroxide ions. Also, a decomplexing agent is added to bind with polyvalent ions such as aluminum and iron, which releases the fluoride ion.

The fluoride electrode is recommended by the United States Environmental Protection Agency in Washington, D.C., for the determination of fluoride from .1 mg/l. Accordingly, the fluoride electrode method was found to be very accurate and precise in a collaborative study by the U.S. Government (United States Environmental Protection Agency, 1986). One hundred and eleven samples were analyzed with .85 mg fluoride per liter with no interferences. The mean was .84 mg/l, and the standard deviation was plus or minus .03. In a continuation of the same study, a sample with .75 mg/l fluoride, 2.5 mg/l polyphosphate, and 300 mg/l alkalinity was analyzed by the same procedure as the first sample using .85 mg/l fluoride. The mean was .75 mg/l fluoride with a standard deviation of plus or minus .036.

Not only is the fluoride electrode ion accurate, sensitive, and precise, but it is convenient. The decomplexing agent which acts as a buffer to bind with interfering substances eliminates the timely distillation step when using calorimetric methods. Also, the fluoride electrode method is ideal for testing fluoride concentrations at the water side due to the advanced automated portable procedure.

Fluoride in Humans

Within two hours from the time fluoride is taken orally (1 mg/ dose), it is cleared from the bloodstream (Menaker, 1980). The average fluoride blood level is about .15 ppm (Menaker, 1980). Ingesting 1 mg fluoride causes the blood level to rise to about 0.25 ppm within one hour. The second hour the blood fluoride returns to the previous (.15 ppm) level. Consequently, daily ingestion of a single dose of 1 mg would not appear to be as effective as a more constant rate of fluoride exposure, which fluoridated drinking water would provide.

Plasma fluoride levels are indistinguishable among populations using .15-2.5 ppm of fluoride in the water but are elevated in individuals whose water supplies 5.4 ppm fluoride (National Research Council, 1971).

Fluoride inhibits not only glycolysis but also oxidative metabolism. "Endolase is subject to inhibition due to the formation of a fluoride-phosphate-magnesium complex" (National Research Council, 1971, pp. 70-71). Fluoride inhibits peroxidase, catalase, and cytochrome oxidase by combining with ferric iron in their home groups. Fluoride inhibits some enzymes that do not have a metal ion requirement but must do so by direct interaction with the enzyme or substrate. However, when a particular pathway is inhibited by fluoride, activation of an alternative pathway is used to a greater degree.

Under normal conditions, fluoride does not affect the human enzyme system, and total fluoride intakes do not alter or impair the liver functioning even up to 100 ppm. The fetus has been found to contain parallel levels of fluoride with the mother; thus, the placenta does not prevent fluoride transfer. However, in mother's milk the fluoride has not been found to exceed .2 ppm. Too much fluoride can alter the bone structure, and mottling can occur with 2 ppm (total dietary intake of diet and water) when the enamel is still forming (Shupe, 1975). However, levels of 4-5 ppm water fluoride on a daily basis may be taken without a problem regarding accumulation in the body. Endemic fluorosis occurs when fluoride levels are greater than 8 ppm/day, whereas industrial contaminations may reach 15-20 mg fluoride per day (Marier, 1977a).

> Life-long residents of communities (which contain naturally occurring fluoride at a concentration of at least 1 ug/ml [1.0 ppm]) suffer no different disease, die at no earlier ages and are not affected in any different manner, physiologically, emotionally, or sociologically, from comparable people residing in similar areas where the communal water supply is fluoride-deficient. (Muhler, 1959, p. 38)

Why Fluoride is Important

> The benefits of fluoride in the public water supply to prevent dental decay have been known since 1945 when fluoride was added to the public water supply (1.0-1.2 ppm) in Grand Rapids, Michigan; Newburgh, New York; and Brantfor, Ontario.
>
> When consumed by children under five in drinking water with a concentration of one part per million (ppm), fluorine will protect teeth from dental caries during childhood and adolescence and preserve them for the use throughout adulthood into old age . . . (Goodheart, 1980, p. 801)

Not only is fluoride of value to children to strengthen teeth and to lessen dental decay but to the aging population as well, in regards to bone density.

> . . . Sodium fluoride in doses ranging from 50-150 mg per day has been under investigation as a treatment for osteoporosis. Both epidemiologic evidence and clinical investigation by balance study and bone density techniques have indicated a potential role for fluoride in prevention and treatment.

(Goodheart, 1980, p. 801)

The per capita annual cost for fluoridation in 1986 was anywhere between 6¢ and 80¢. According to Karen L. Zinner (personal communication, October 1986), Coordinator of Dental Disease Prevention at the Utah Dental Health Bureau and Fluoride Specialist for the State Health Department, the cost of fluoride in the 1980s was about 25¢ per year. In 1986 the cost was approximately 35¢ per year. Variations will occur according to large cities versus small towns, old versus new equipment, and cold versus warm climates.

CHAPTER II

THE PURPOSE OF THE STUDY

The interactions which occur between the fruit, the soil it's grown in, and the fertilizers have been discussed. The purpose of this study was to determine whether or not the fluoride content in home-canned fruits reflects the fluoride level of the water in which it was canned.

Materials and Methods

Four cities were chosen. Two experimental cities were fluoridated: Brigham City and Helper. Two control cities, North Ogden and Price, were not fluoridated. From each of the four cities three homes were selected. From each home one bottle each of apricots, cherries, and peaches was collected. In addition, a water sample (from the tap water used in canning) was also collected. Qualifications for homes chosen included: (1) fruit grown in that region, (2) fruit canned in that region, (3) fruit canned using the main water supply, and (4) fruit canned during the summer of 1981.

The samples were collected by the Utah State University Extension Service home agent in that city. The samples took nearly one year to collect. When the samples arrived they were weighed separately, according to the juice and the pulp, using a strainer, and subtracting the weight of the container. Smaller portions were then weighed out, freeze-dried, and weighed again to determine the percent moisture. A Baum hydrometer was used to determine the percent sugar in the juice based on the principle of specific gravity.

A total ionic strength adjustor (TISAB), to break the aluminum and iron fluoride complexes, was mixed with the water samples (50% TISAB with 50% water). The process provided a constant background ionic strength, decomplexed the fluoride, and adjusted the solution pH (Orion Research Incorporated, 1977). The total ionic strength adjustment buffer consisted of glacial acetic acid, sodium chloride, and sodium citrate. Samples of the diluted solutions were titrated with 5 M NaOh.

After the water standards were run (.1 ppm, 1 ppm, 5 ppm, and 10 ppm), a line was determined on semi-logrithmic paper to calculate the parts per million (ppm) fluoride in fruit pulp from the MV readings. The juice and water samples were run using the same procedure. Readings for juice and water samples were taken after five minutes of stabilization using the stir bar and the ion electrode.

The pulp was analyzed according to the AOAC method for vegetation fluoride. The samples had been freeze-dried and placed in a desiccator. The freeze-dried samples were then pounded into a fine powder in a mortar with a pestle. Approximately .25 gms each of the freeze-dried apricot, cherry, and peach powders were weighed. Twenty ml of .05 H NO3 were placed in a 50-ml beaker with each sample and stirred for 20 minutes. Twenty ml of .1 N KOH were added to each sample and allowed to stand for an additional 20 minutes. Five ml of sodium citrate solution containing 1 ppm fluoride (adjusted to pH 5.5) was then added. Finally, five ml .2 N HNO3 were added. The samples were allowed to stabilize approximately five minutes before the reading was taken. The fluoride standards were .1 ppm, .2 ppm, .3 ppm, .5 ppm, 1 ppm, 3 ppm, 5 ppm, and 10 ppm in water, a linear correlation of .99, an intercept of .01, and a slope of .08 for MV reading which is the concentration of (Log [10]).

Recovery of Fluoride in Spiked Pulp and Water Samples

Eight fruit samples were chosen to determine whether or not there was a difference between the fluoride recovery in apricots, cherries, and peaches. Four samples were spiked with 4 ml (100 ppm) fluoride standard. The samples were ashed and analyzed. The recovery was 101% for apricots, 103% for cherries, and 101% for peaches. This was based upon the estimated value divided by the spiked value times 100. The average for the % recovery was 101.66 with a standard deviation of 1.22. A 1-3% margin of error may have accounted for a greater than 100% recovery, although each of the four results was within a narrow range. This assumes that there is little or no significant difference between the recovery of fluoridated spikes from each of the four fruits.

Cherry juice was spiked with .05, .10, and .15 ppm fluoride to determine a difference in recovery according to increments of fluoride. The results of spiking indicated 96%, 90%, and 29% recovery, respectively. The lower limits of detection for the fluoride electrode are .1 mg/l; however, the Water Research Lab at the Utah State Department of Health uses .05 mg/l as the minimal detectable limit. This may indicate that as fluoride increases, the recovery may decrease, possibly due to the decreased sensitivity of the method to determine fluoride content. The exact reason is unknown. However, this spiking does indicate that the fluoride values are within a 4-11% range of the actual values.

Five blind, spiked water samples were run. The results came so close to the actual value of the spiked samples that the correlation was .99. This indicates that the water fluoride values obtained in this research are reliable. Furthermore, the State Department of Health recorded fluoride water levels of .07 and .15 ppm for Brigham City and Helper, while values of .096 and .145 were observed in this research. The agreement between collected data and that of the State Department indicates reproduceability of experimental procedure. Results of data are recorded in Table 4.

Table 4. Recovery of fluoride in spiked water samples.

Unknown	Obtained values	Actual values	% actual
A	.09	.10	90
B	.46	.50	92
C	1.02	1.00	102
XY	.65	.68	96
X	.35	.36	97

Note: Readings were taken after 10 minutes of stabilization. (LR = .99)

CHAPTER III

RESULTS

Water values (Table 5) in North Ogden had slightly greater concentrations of fluoride than in Price for the nonfluoridated cities. Helper had greater concentrations of fluoride in the water than Brigham City in the fluoridated areas. The fluoride concentrations in water decreased from the north to the south in the nonfluoridated cities and increased in fluoride concentrations from north to south in the fluoridated areas.

Table 5. Fluoride content of juice from some canned fruits (ppm).

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apples	.1040	.0847	.0624	.0740	.0813	.01768
Cherries	.0596	.0580	.0929	.0838	.0736	.01747
Peaches	.0534	.0818	.1102	.0734	.0797	.02360
Overall	.0723	.0748	.0885	.0770	.0782	.00716

Brigham City, a fluoridated city, had by far the lowest water fluoride level (.096 ppm), while North Ogden (.159 ppm), an unfluoridated city, had the highest (Table 5). Helper, Price, and North Ogden (.145 ppm, .153 ppm, .159 ppm) had comparable values. The fact that in Brigham City, the fluoridator was not working at the time the water samples were taken accounts for this. Also, some of the samples were collected during the summer, others in the fall, still others in the spring, and again the following summer.

The fluoride levels in juice for apricots, cherries, and peaches in the nonfluoridated cities were very close (Table 6). There was greater variation in the fluoride levels in juice between the two fluoridated cities, Brigham City and Helper, than was found for the nonfluoridated cities.

Table 6. Fluoride content for lypophilized pulp from home-canned fruits (ppm).

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apricots	6.63	5.47	4.51	7.96	6.14	1.490
Cherries	7.36	4.48	5.17	3.24	5.06	1.727
Peaches	5.34	5.67	3.43	2.87	4.33	1.385
Overall	6.44	5.21	4.37	4.69	5.18	.910

Regarding fluoride concentration in the pulp (Table 7), Helper (4.37 ppm) had the lowest average, while Brigham City (6.44) had the highest and North Ogden (5.21) was in the middle. Price and Helper were relatively close (4.69 and 4.37 respectively).

The fluoride in the fruit pulp (Table 7) was greater in North Ogden for cherries and peaches than for Price but was greater for apricots in Price. For the fluoridated cities, apricots, cherries, and peaches all had greater fluoride levels in the fruit pulp in Brigham City.

The overall average of fluoride level in apricots, cherries, and peaches was very much the same in the fluoridated cities as with those cities which were not fluoridated. The fluoride level in the pulp

Table 7. Fluoride content for tap water from homes - water fluoride (ppm).

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apricots	.0934	.1591	.1454	.1532	.1378	.0301
Cherries	.0987	.1591	.1454	.1532	.1391	.0275
Peaches	.0987	.1591	.1454	.1532	.1390	.0275
Overall	.0969	.1591	.1454	.1532	.1387	.0284

Note: Water samples were taken from each home from which the fruit samples were collected. Thus, for each bottle of canned apricots, cherries, and peaches, a bottle of water was collected from the tap from which water had been taken for fruit to be canned. However, the water sample was collected at a time different from when the fruits were canned.

(Table 7) of peaches was very similar in the fluoridated versus nonfluoridated cities, whereas cherries had approximately twice the fluoride in the fluoridated cities than in the nonfluoridated cities. Apricots were similar in fluoride for dry pulp in Brigham City and Ogden (6.63 ppm, 5.47 ppm) but were higher in Price (7.96 ppm).

The percent juice (Table 8) with all three fruits (apricots, cherries, and peaches) was quite close in range, although Brigham City had the lowest (31.4%). For North Ogden, Price, and Helper, the values appeared to cluster (42.6%, 40.1%, 40.0%).

There was little variation in percent juice (Table 8) for apricots between fluoridated and nonfluoridated cities. Cherries were also

Table 8. Percent juice in canned fruit.

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apricots	37.35	42.68	36.36	40.39	39.20	2.89
Cherries	32.09	38.46	45.47	43.79	39.95	6.03
Peaches	25.01	46.80	38.32	36.13	36.57	8.97
Overall	31.48	42.65	40.05	40.10	38.57	4.88

consistent with a greater percentage of juice per bottle of fruit for Price and Helper. For peaches, North Ogden and Helper had a greater percentage of juice per bottle of fruit than did Price and Brigham City.

The percent juice (Table 8) was less for apricots, cherries, and peaches from the fluoridated cities versus the nonfluoridated cities. There was greater variation between percent juice in cherries and peaches in the fluoridated cities. Cherries had the highest and peaches, the lowest percent juice. In the nonfluoridated cities, the percent juice of apricots, cherries, and peaches was nearly equal.

The percent dry matter (Table 9) for North Ogden and Helper was close in range (19.2%, 20.4%), and Price and Brigham City were also close in range (14.5%, 16.3%), although all values were relatively homogeneous.

The percent dry matter (Table 9) per bottle of canned apricots, cherries, and peaches was greater in North Ogden than in Price and was greater for apricots in Brigham City than in Helper. Helper had a greater percent dry concentration per bottle of canned fruit for cherries and peaches.

Table 9. Percent dry matter of solids in home-canned fruits.

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apricots	14.84	17.38	13.19	10.18	13.19	3.02
Cherries	19.61	23.49	29.90	19.41	23.10	4.91
Peaches	14.67	16.92	18.38	14.03	16.00	2.01
Overall	16.37	19.20	20.49	14.54	17.67	2.71

The greatest variation in percentage dry matter (Table 9) among fruits was with cherries. The fluoridated cities had the greater percent in dry matter.

There was approximately 50 percent more sugar in fruits canned in Helper than in fruits canned in Price (Table 10). (Percentages were Price, 9.8%; North Ogden, 16.3%; Helper, 18.3%; and Brigham City, 13.6%).

Table 10. Percent sugar in juice of home-canned fruits.

	Brigham	Ogden	Helper	Price	Overall	Standard deviation
Apricots	12.46	14.53	15.53	5.23	11.91	8.32
Cherries	16.03	19.90	23.56	14.16	18.41	4.18
Peaches	12.43	14.53	16.10	10.13	13.30	2.59
Overall	13.64	16.32	18.36	9.84	14.54	3.68

The greatest difference among samples for percent sugar (Table 10) was in the juice of canned apricots. The least difference was among peaches. For all fruits and all cities, cherries canned in Helper had the greatest sugar content of all. Cherries had the greatest percent sugar as compared to apricots, cherries, and peaches (Table 11).

Table 11. Overall comparison of pulp, juice, and water in % juice, % dry, and % sugar in home-canned fruits for fluoridated vs. nonfluoridated cities.

14	Fluoridated	Nonfluoridated	Apricot	Cherry	Peach	Standard deviation
Water, ppm F[a]	.121	.156	.137	.139	.139	.012
Juice, ppm F	~~.080~~ .084	.075	~~.081~~ .0932	.073	~~.079~~ .073	.328
Pulp, ppm F	5.400	~~4.940~~ 4.67	~~6.140~~ 5.800	5.060	~~4.320~~ 4.240	.667
Juice, %	37.000	41.300	39.100	39.900	36.500	1.870
Dry, %[b]	18.400	16.900	13.900	23.100	16.000	3.450
Sugar, %	16.000	13.000	11.900	18.400	13.300	2.640

[a] Tap water was obtained from homes.

[b] Percent dry matter in fruit portion.

Statistically, the results of the study did not show a significant concentration difference in the fluoride content for the pulp (Table 12), the water (Table 13), or the percent juice (Table 14). However, statistically there was significance in the juice data (Table 15) with the interaction between the fruit and the fluoridated or nonfluoridated city water supply.

There was also a significant difference in the percent dry matter (Table 16) of the fruit dependent upon whether or not the cities were fluoridated. In addition, there was statistical significance among cities in the percent dry matter of the fruit. When the LSD test was done at the .05 percent probability level, however, a difference among

Table 12. Anova for fluoride in dry pulp (ppm).

SV	DF	SS	MS	F
Fluoride	1	1.886044	1.886044	1.000
Cities/F	2	20.545479	10.272739	1.745
Homes/C/F	8	47.089781	5.886223	
Fruit	2	20.003399	10.001699	1.797
Fl X Fr	2	19.473158	9.736579	1.749
Fr X C/F	4	22.266355	5.566589	1.851
Fr X H/C/F	16	48.105083	3.006568	
Total	35	179.369300		

Note: No statistical significant differences among the means of dry pulp (ppm).

the fruits was not found.

Likewise, there was a statistical significance in the percent sugar with the fruits (Table 17), but again, when the LSD test was done (at the .05 level), there was no difference among the fruits.

On a correlation matrix, there was a good correlation (.875) between fluoride in the pulp (ppm) and the percent dry matter. On the other hand, there was relatively no correlation (.021) with fluoride in the juice (ppm) and the tap water (ppm), or with the percent juice and the pulp (ppm) (.035).

Table 13. Anova for fluoride in water (ppm).

SV	DF	SS	MS	F
Fluoride	1	.011018	.011018	2.050
Cities/F	2	.010748	.005374	2.573
Homes/C/F	8	.016711	.002089	
Fruit	2	.000014	.000007	1.000
Fl X Fr	2	.000014	.000007	1.000
Fr X C/F	4	.000027	.000007	1.000
Fr X H/C/F	16	.000110	.000007	
Total	35	.038642		

Note: No statistical difference among means for water (ppm).

Table 14. Anova for percent juice in canned fruit (per bottle fruit).

SV	DF	SS	MS	F
Fluoride	1	283.2489	283.2489	1.578
Cities/F	2	359.0457	179.5228	1.811
Homes/C/F	8	793.1921	99.1490	
Fruit	2	75.7957	37.8979	1.000
Fl X Fr	2	87.4207	43.7103	1.000
Fr X C/F	4	397.8647	99.4662	1.562
Fr X H/C/F	16	1019.0894	63.6931	
Total	35	3015.6571		

Note: No statistical difference among means for percent juice per jar.

Table 15. Anova for fluoride in juice.

SV	DF	SS	MS	F
Fluoride	1	.000179	.000179	1.000
Cities/F	2	.001204	.000602	1.000
Homes/C/F	8	.005433	.000679	
Fruit	2	.000397	.000198	1.000
Fl X Fr	2	.000004	.000002	1.000
Fr X C/F	4	.009171	.002293	4.177*
Fr X H/C/F	16	.008791	.000549	
Total	35	.025178		

*Significant at the .05 level probability.

Note: Statistical significance for juice (ppm) for the city in which the fruit was canned.

Table 16. Anova for percent dry matter in pulp of canned fruit.

SV	DF	SS	MS	F
Fluoride	1	21.0528	21.0528	1.000
Cities/F	2	176.6024	88.3012	1.825
Homes/C/F	8	387.1316	48.3915	
Fruit	2	558.1414	279.0707	9.129*
Fl X Fr	2	15.1953	7.5976	1.000
Fr X C/F	4	122.2790	30.5698	3.500
Fr X H/C/F	16	139.7577	8.7349	
Total	35	1420.1602		

*Significant at the .05 level of probability.

Note: Statistical significance for percent dry matter in pulp for canned fruit.

Table 17. Anova for percent sugar in juice of canned fruit (per bottle fruit).

SV	DF	SS	MS	F
Fluoride	1	76.8544	76.8544	1.000
Cities/F	2	289.1744	144.5872	2.782
Homes/C/F	8	415.7133	51.9642	
Fruit	2	281.3755	140.6878	15.046*
Fl X Fr	2	6.9356	3.4678	
Fr X C/F	4	37.4022	9.3506	1.000
Fr X H/C/F	16	302.8334	18.9271	
Total	35	1410.2889		

*Significant at the .05 level of probability.

Note: Statistical significance for percent sugar in juice of canned fruit.

CHAPTER IV

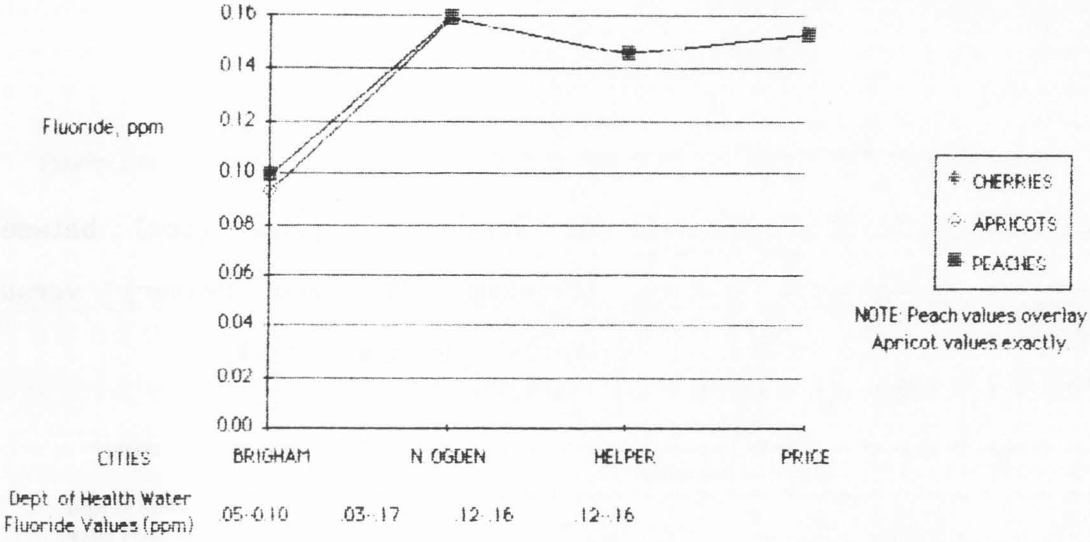
DISCUSSION

Fruit from homes in North Ogden had the highest (ppm fluoride) water value for apricots, cherries, and peaches, while fruit from homes in Brigham City had the lowest (Figure 1). Peaches (Figure 2) contain the lowest fluoride concentration in the juice for Brigham City with the highest fluoride in the juice for Helper when comparing apricots and cherries. The statistically significant value for the fruit juice (Table 15) may be accounted for by the variation in fluoridation in the water in which it was canned (Figure 2). There is the possibility that the fluoridator was working in Helper when peaches and cherries were canned but not working during the canning season for apricots. Alternatively, the fluoridator may have been working during the canning season for apricots but not working during the canning season for cherries and for peaches.

However, apricots (Figure 3) contained the greatest amount of fluoride in the dry pulp in Price, with peaches containing the least amount of fluoride for that same city. Price had the greatest variation among fruits when comparing the amount of fluoride in the pulp for all cities.

In comparing fruits for percent of juice within each jar, peaches from Brigham City had the greatest variability with the lowest percent juice for peaches and North Ogden, the highest. This may well reflect differences in canning practices in the four cities. As seen in Figure 4, the percent juice per jar of fruit correlated closely for peaches and

Figure 1. Fluoride levels of water obtained from the homes of fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).



NOTE: Peach values overlay Apricot values exactly

Figure 2. Comparison of fluoride levels in juice (ppm) between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

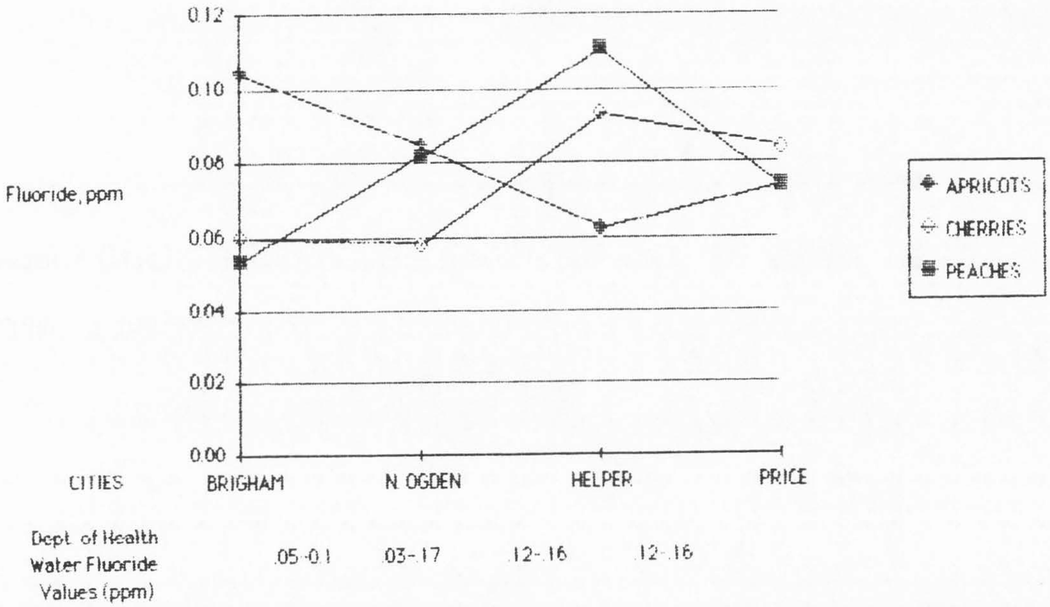

0.12
0.10
0.08
0.06
0.04
0.02
0.00
Fluoride, ppm
APRICOTS
CHERRIES
PEACHES
CITIES
BRIGHAM
N OGDEN
HELPER
PRICE
Dept. of Health
Water Fluoride
Values (ppm)
.05-0.1
.03-.17
.12-.16
.12-.16

Figure 3. Comparison of fluoride levels in dry pulp (ppm) between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

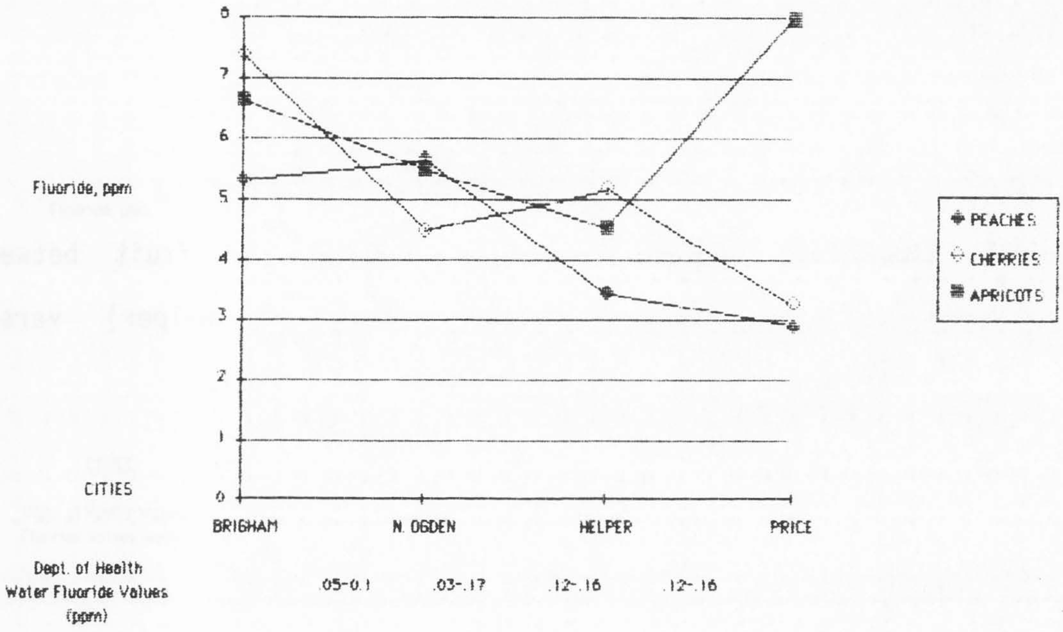
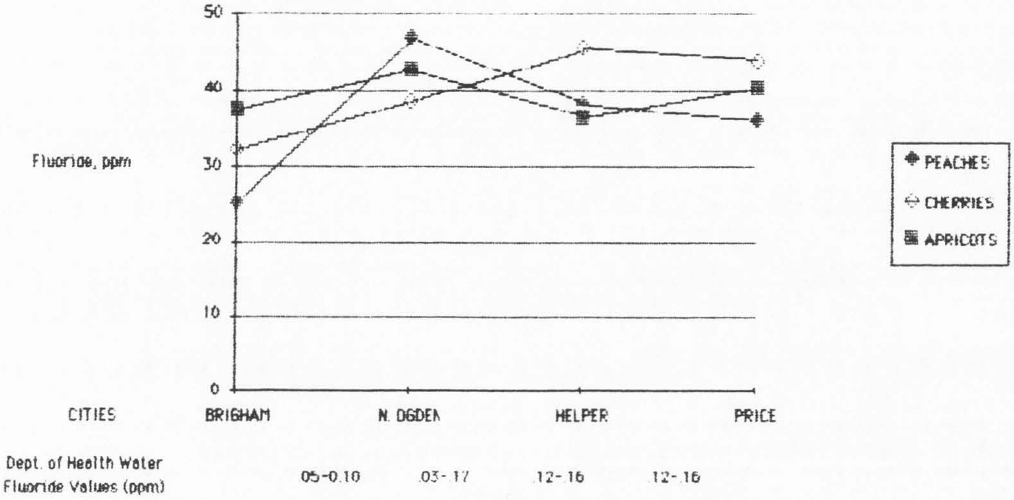

Fluoride, ppm
8
7
6
5
4
3
2
1
0
CITIES
BRIGHAM
N. OGDEN
HELPER
PRICE
Dept. of Health
Water Fluoride Values
(ppm)
.05-0.1
.03-.17
.12-.16
.12-.16
PEACHES
CHERRIES
APRICOTS

Figure 4. Comparison of percent juice per jar of fruit between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).


50
40
30
20
10
0
Fluoride, ppm
CITIES
BRIGHAM
N. OGDEN
HELPER
PRICE
Dept. of Health Water Fluoride Values (ppm)
05-0.10
.03-.17
.12-.16
.12-.16
PEACHES
CHERRIES
APRICOTS

apricots in North Ogden and in Helper.

Cherries had the greatest percent dry matter in all four cities, with the greatest percent dry in Helper (Figure 5). Conversely, apricots had the lowest percent dry in Price, followed by Helper. Peaches and apricots had similar values in percent dry matter in both Brigham City and North Ogden.

The percent sugar in juice of canned fruits correlates closely with the percent dry matter in pulp for cherries. The same is true for peaches and apricots in Price (Figure 6).

Figure 7 illustrates similarities between water fluoride values among apricots, cherries, and peaches in fluoridated cities and also similarities among these fruits in nonfluoridated cities. The fluoride content in juice was consistently greater for apricots, cherries, and peaches from fluoridated cities than it was for the nonfluoridated cities (Figure 8). This indicates that at the time of canning, the fluoridator must have been working.

However, in Figure 9, only cherries and peaches had a greater fluoride content in fluoridated cities than in the nonfluoridated cities, with cherries taking the lead. Apricots had greater fluoride in the nonfluoridated cities. The nonfluoridated cities had a greater percent juice per jar for apricots, cherries, and peaches than did the fluoridated cities, as seen in Figure 10.

Apricots, cherries, and peaches all had a greater percent dry matter (Figure 11) in the fluoridated cities than in the nonfluoridated cities, with cherries having the greatest percent dry among the fruits. The same was true for percent sugar per sample, with cherries having the greatest percent sugar among the fruits in the fluoridated cities,

Figure 5. Percent pulp in canned fruit for fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

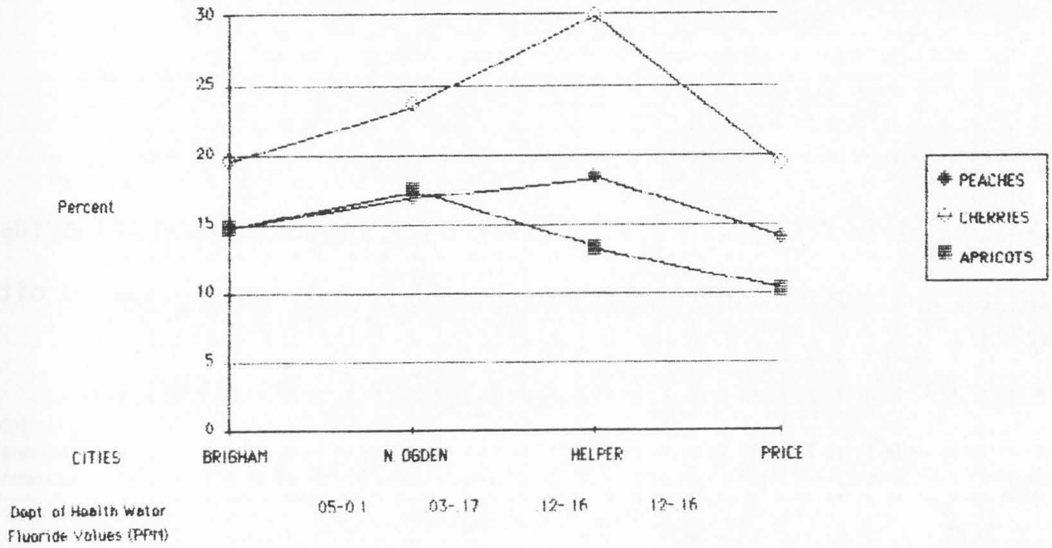

30
25
20
15
10
5
0
Percent
CITIES
BRIGHAM
N. OGDEN
HELPER
PRICE
Dept of Health Water
Fluoride Values (PPM)
05-0.1
.03-.17
.12-.16
12-.16
PEACHES
CHERRIES
APRICOTS

Figure 6. Comparison of percent sugar in juice between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

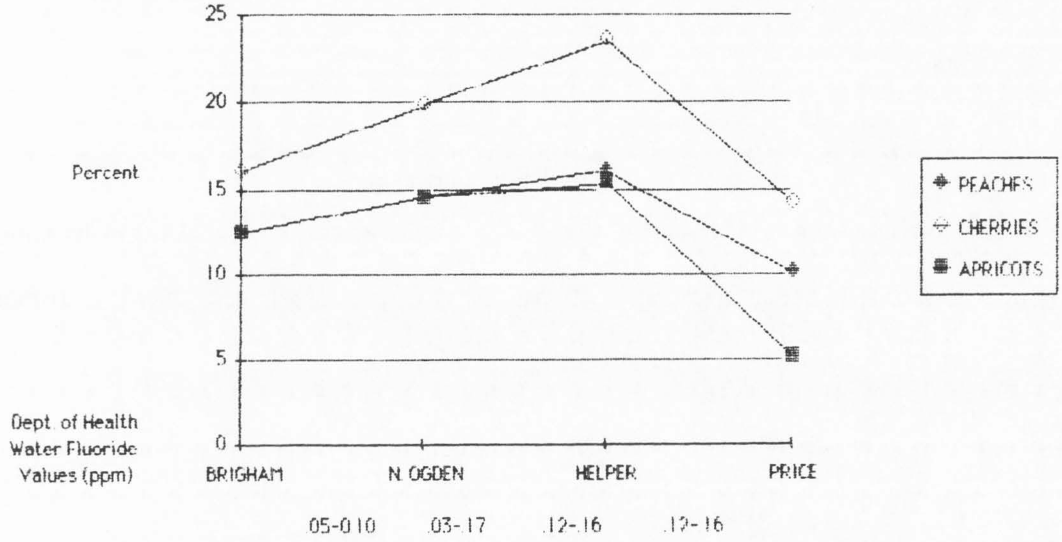

25
20
Percent
15
10
5
0
Dept. of Health
Water Fluoride
Values (ppm)
BRIGHAM
N. OGDEN
HELPER
PRICE
05-0.10
.03-.17
.12-.16
.12-.16
PEACHES
CHERRIES
APRICOTS

Figure 7. Comparison of fruits for fluoride content in water between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

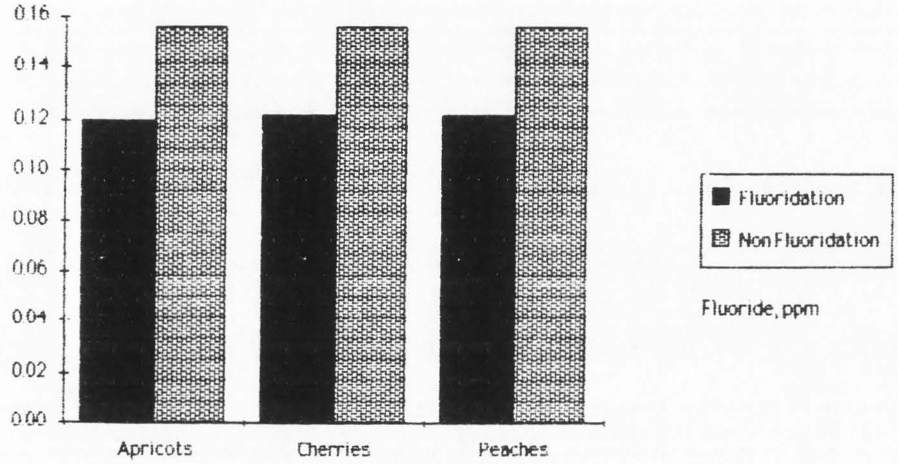

0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
Apricots
Cherries
Peaches
■ Fluoridation
▨ Non Fluoridation
Fluoride, ppm

Figure 8. Comparison of fruits for fluoride content in juice between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

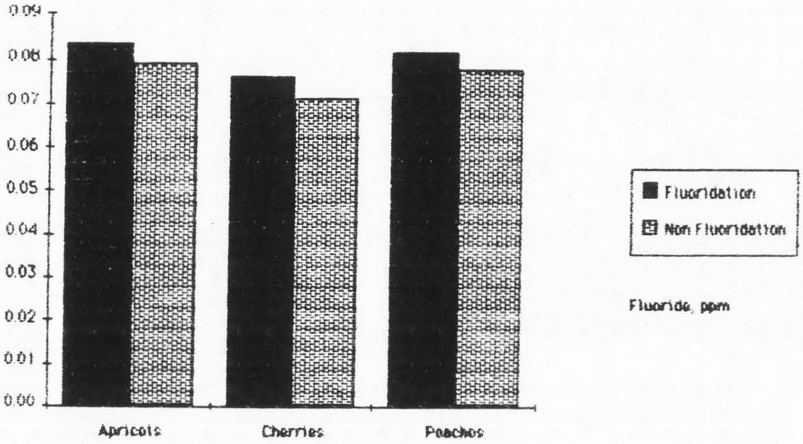

0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
Apricots
Cherries
Peaches
Fluoridation
Non Fluoridation
Fluoride, ppm

Figure 9. Comparision of fruits for fluoride level in fruit pulp between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

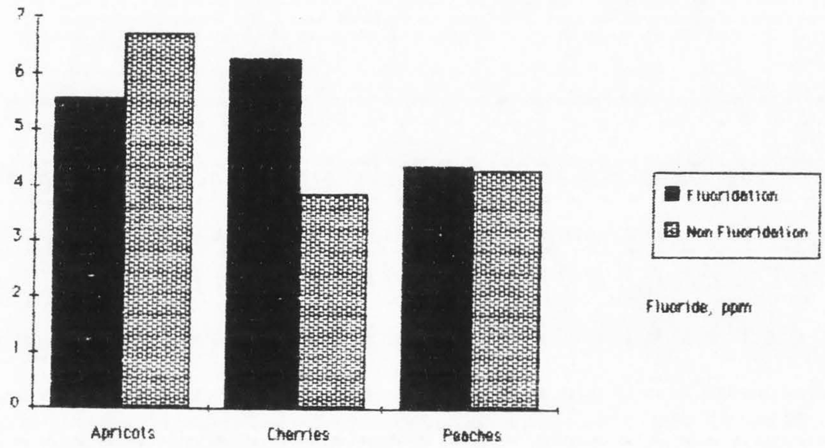

7
6
5
4
3
2
1
0
Apricots
Cherries
Peaches
■ Fluoridation
▨ Non Fluoridation
Fluoride, ppm

Figure 10. Comparison of fruits for percentage of dry matter (per fruit sample) between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

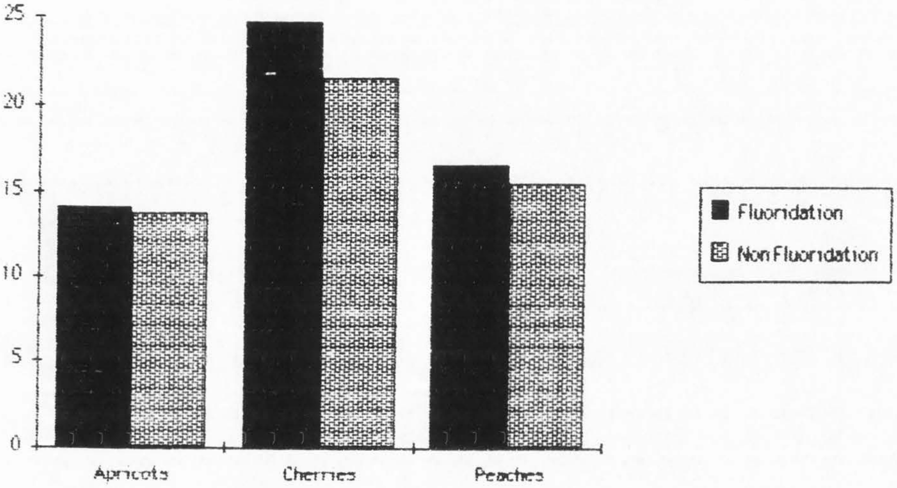
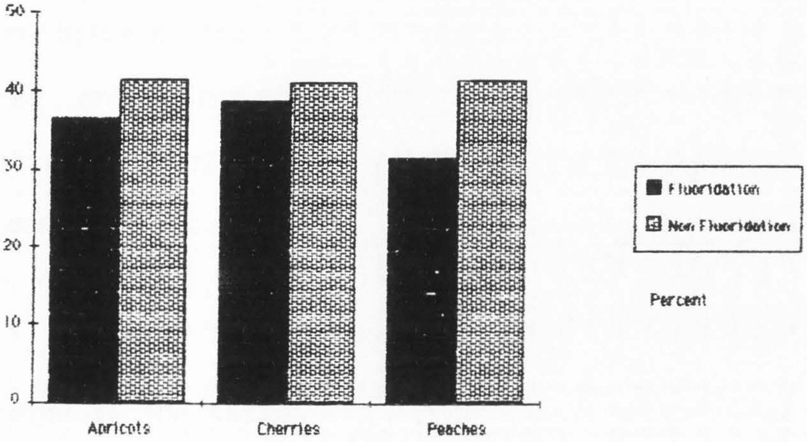

25
20
15
10
5
0
Apricots
Cherries
Peaches
Fluoridation
Non Fluoridation

Figure 11. Comparison of fruits for percentage of juice (per container) between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).

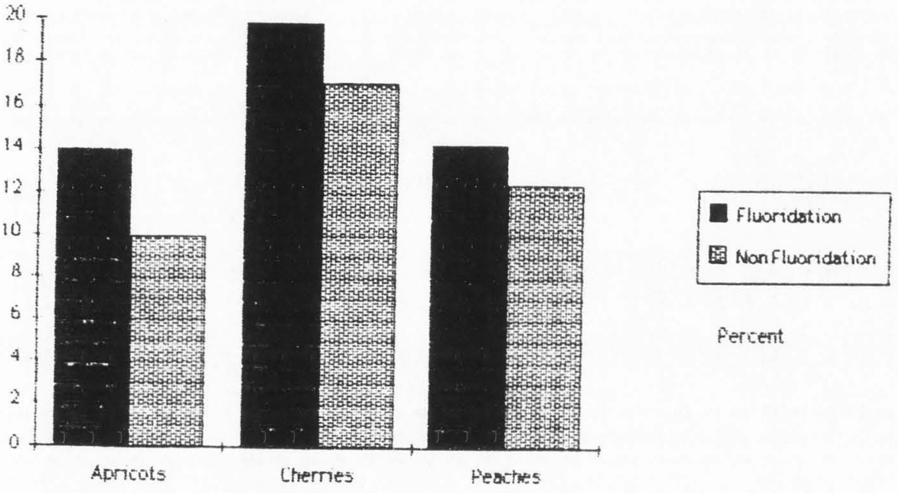

50
40
30
20
10
0
Apricots
Cherries
Peaches
Fluoridation
Non Fluoridation
Percent

although apricots had the greatest difference between the percent sugar per sample in the fluoridated versus nonfluoridated cities (Figure 12).

As seen in Table 17, the fluoride in the juice was significant in the fruits depending on whether or not the city was fluoridated. There was no significant difference for the fluoride in the dry pulp for either the main effects or for the interactions (Table 12). The same was true for the fluoride in the water (Table 13) and for ANOVA for percent juice in canned fruit per bottle fruit (Table 14). However (Table 16), the ANOVA for canned fruit indicated a statistically significant difference among fruits for percent dry, as well as the interaction between fruits and the city the fruit was canned in (fluoridated or not). Finally, there was also a statistically significant difference (Table 17) for fruits with the percent sugar in juice of canned fruit per bottle of fruit. These differences may be attributed to a variation in canning recipes calling for differing amounts of sugar.

According to the National Research Council (1971), drinking water provides from 1-1.5 mg fluoride in fluoridated areas and .1-.6 mg fluoride in nonfluoridated areas. The combination of water and diet provides approximately 1 mg/day in low fluoride areas to approximately 4 mg/day in a fluoridated area. The Food and Nutrition Board (National Research Council, 1980) indicates that the average fluoride intake for fluoridated areas is 2.63 mg plus or minus .17 g/day, while in the nonfluoridated areas the values averaged .91 mg plus or minus .05 mg/day. These Utah results for the fluoridated area were .12 ppm fluoride and were .15 ppm fluoride for the nonfluoridated areas. However, in spite of problems such as the fluoridator not working, the overall juice

Figure 12. Comparison of fruits for percent sugar between fluoridated cities (Brigham City and Helper) versus nonfluoridated cities (North Ogden and Price).


20
18
16
14
12
10
8
6
4
2
0
Apricots
Cherries
Peaches
Fluoridation
Non Fluoridation
Percent

and pulp values were slightly higher in the fluoridated areas than in the nonfluoridated areas (juice .080, .075; pulp 5.40, 4.94 respectively). This higher overall average of fluoride in juice and pulp may indicate fluoride levels over a period of time rather than a single sample taken with the water, when the fluoridator was not working.

McClure (1970) and others found a range of fluoride concentration for noncitrus fruits to be .45-12 ppm. In this study, the overall average of apricots, cherries, and peaches in both fluoride and nonfluoridated areas was 5.17 ppm, on a dry-weight basis, for the pulp (Figure 3). This 5.17 ppm is within the acceptable range of expected values.

Apricots had the greatest fluoride content (6.14 ppm), with cherries (5.06 ppm) and peaches (4.32 ppm) following in descending order. The calculated amount of fluoride in an eight-ounce portion of fruit containing from .86-1.17 ppm fluoride, on a wet-weight basis, would be approximately .195-26.4 mg fluoride per serving.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Periodically through the year, there were problems with the fluoridator and its operation. The practical and mechanical aspects of maintaining the fluoridator for a public water system have a bearing on the total fluorine intake of a population. The pulp and juice values were slightly higher in the fluoridated cities versus the nonfluoridated cities, although the water values were the opposite of what would have been expected. The juice and the pulp appear to correlate more closely than the juice and the water, or the water and the pulp. There is slightly more pulp fluoride in the Utah fluoridated cities studied than in the nonfluoridated cities; however, the differences are not significant.

Recommendations

Recommendations for further research on the fluoride content in home-canned fruits would include a control and an experimental group of canned fruits in a laboratory setting to minimize uncontrollable variables such as whether or not the fluoridator was working.

Fluoride standards could be built into the experiment by adding increments of fluoride to numerous bottles of fruit. Factors such as temperature during canning, storage time and conditions, standardization of recipes, type of fruit, soil pH, and environmental contamination variations could all be held as a constant.

This method, however, would not reflect the amounts of fluoride in home-canned fruits in the community but instead would measure the effects of fluoride retention as the result of canning.

BIBLIOGRAPHY

Alder, P. 1970. Fluorides and Human Health. World Health Organization, Geneva. 59 pp.

American Academy of Pediatrics, Committee on Nutrition. 1972. Fluoride as a nutrient. Pediatrics 49:456-460.

Anderson, L. 1982. Nutrition in Health and Disease. Lippincott Co., Toronto. 794 pp.

Bention, W. 1984. Fluorine. Encyclopaedia Britannica Micropaedia, Inc. 15th Ed. Encyclopaedia Britannica Inc., Chicago. 1050 pp.

Bernstein, D. S., N. Sadowsky, D. M. Hegsted, C. D. Guri, and F. J. Stare. 1966. Prevalence of osteoporosis in high- and low-fluoride areas in North Dakota. J. Am. Med. Assoc. 198:499-504.

Cass, R. M., J. D. Croft Jr., P. Perkins, W. Nye, C. Waterhouse, and R. Terry. 1966. New bone formation in osteoporosis following treatment with sodium fluoride. Arch. Intern. Med. 118:111.

Chapman, S. K., M. H. Malagodi, and W. C. Thomas Jr. 1978. Effect of vitamin D in fluoride-treated rats. Clin. Orthop. Relat. Res. (130):289-296.

Cholak, J. 1960. Current information on the quantities of fluoride found in air, food, and water. Arch. Ind. Health 21:312.

Cohen, E., and R. A. Van Dyke. 1979. Fluoride from anesthetics and its consequences. In E. Johansen, D. R. Taves, and T. O. Olsen (Eds.), Continuing Evaluation of the Use of Fluorides (pp. 231-249). West View Press, Colorado. 321 pp.

Dabeka, R. 1981. Microdiffusion and fluoride specific electrode. Determination of fluoride in infant foods: Collaborative study. J. Assoc. Off. Anal. Chem. 64(4):1021-1026.

Duxbury, A. 1982. Acute fluoride toxicity. Br. Dent. J. 153:64.

Ericsson, Y. 1971. Wide variations of fluoride supply to infants and their effect. Caries Res. 5:78-88.

Federal Register. 1985. National primary drinking water regulations. Fluoride; final rule and progressed rule. Environmental Protection Agency, Washington, D.C. 50:220, 47158-47159.

Filler, R. 1982. Biochemical Aspects of Fluorine Chemistry. Elsevier Biochemical Press, New York. 246 pp.

Foman, S. 1978. Nutritional disorders of children; prevention screening and followup. (HSA) (78-5104). United States Department of Health, Education and Welfare, Washington, D.C. 123 pp.

Glen, F. 1982. Fluoride tablet supplementation during pregnancy for caries immunity: A study of the offspring produced. Am. J. Obste. Gyn. 143(5):560-564.

Goodheart, R. 1980. Modern Nutrition in Health and Disease. 6th Ed. Aea and Febiger, Philadelphia. 1370 pp.

Goodman, L., and A. Gilman. 1975. Fluoride, the pharmacological basis of therapeutics. 5th Ed. Macmillan Pub. Co., New York. 1704 pp.

Heifetz, S. 1981. Alternative methods of delivering fluorides: An update. National Institutes of Health, Washington, D.C. (81-2235): 25-42.

Hicks, M. 1983. The effects of acid-etching on caries-like lesions treated with stannous fluoride. J. Dent. Res. 62(7):783-788.

Kramer, L., D. Osis, E. Wiatrowski, and H. Spencer. 1974. Dietary fluoride in different areas in the United States. Am. J. Clin. Nutr. 27:590-594.

Marier, J. 1977a. Environmental fluoride. Associated Committee on Scientific Criteria for Environmental Quality, National Research Council, Ottawa, Ontario. 151 pp.

Marier, J. 1977b. Some current aspects of environmental fluoride. The Sci. of Total Environ. (8):253-265.

Mazza, J. 1981. Clinical and antimicrobial effect of stannous fluoride on periodontitis. J. of Clin. Periodon. 8:203-212.

McClure, F. 1970. Water fluoridation, the search and the victory. National Institute of Dental Research, Bethesda. 302 pp.

Menaker, L. 1980. The Biologic Basis of Dental Caries. Harper & Row Publishers, New York. 532 pp.

Muhler, J. 1959. Fluoride and Dental Health. The Pharmacology and Toxicology of Fluorine. Indiana University Press, Bloomington. 216 pp.

Muhler, J. C. 1970. Fluoride and Human Health. World Health Organization, Geneva. 364 pp.

Murray, J. 1976. Fluorides in Caries Prevention. John Wright & Sons, Ltd., Bristol. 195 pp.

National Research Council, Committee on Biological Effects of Atmospheric Pollutants. 1971. Effects of Atmospheric Pollutants, Fluorides. National Academy of Science, Washington, D.C. 295 pp.

National Research Council. 1980. Recommended Dietary Allowances. 9th Ed. National Academy of Science, Washington, D.C. 186 pp.

Ophaug, R. H., L. Singer, and B. F. Harland. 1980. Estimated fluoride intake of average two-year-old children in four dietary regions of the United States. J. Dent. Res. 59(5):777-781.

Orion Research Incorporated. 1977. Fluoride Electrode Manual. Cambridge, Author. 12 pp.

Osis, D., L. Kramer, E. Wiatrowski, and H. Spencer. 1974. Dietary fluoride intake in man. J. Nutr. 104:1313-1318.

Scharret, R. 1982. Components of variation in lead, cadmium, copper, and zinc concentration in home drinking water: The Seattle study of trace metal exposure. Environ. Res. (28):276-278.

Shroy, R. 1982. Proton activation analysis for the measurement of fluoride in food samples. Anal. Chem. 54:407-413.

Shupe, L. 1975. Efficiency and Safety of Fluoridation. American Medical Association, Chicago. 17 pp.

Singer, L., R. H. Ophaug, and B. F. Harland. 1980. Fluoride intake of young male adults in the United States. Am. J. Clin. Nutr. 33:328.

Spencer, H., I. Lewin, E. Wiatrowski, and J. Samachson. 1970. Fluoride metabolism in man. Am. J. Med. 49:807.

Taves, D. 1983. Dietary intake of fluoride ashed (total fluoride) v. unashed (inorganic fluoride) analysis of individual foods. Brit. J. Nutr. 49(3):295.

Taves, D. R., T. L. Olsen, and E. Johansen. 1979. Continuing evaluation of the use of fluorides. American Association for the Advancement of Science Selected Symposium. West View Press, Colorado. 321 pp.

United States Department of Agriculture. 1968. Household food consumption survey 1965-1966. Agricultural Research Service, Washington, D.C. Reports 2-5.

United States Environmental Protection Agency. 1986. Monitoring for fluoride in drinking water. Scientific and Technology Branch, Criteria and Standards Division, Office of Drinking Water, Washington, D.C. 26 pp.

Venkateswarlu, P. 1982. Sodium biphenyl method for determination of covalently bound fluoride in organic compounds and biological materials. Anal. Chem. 54:1132-1137.

Venkateswarlu, P. 1984. Reverse extraction technique for the determination of fluoride in biological materials. Anal. Chem. 46(7):878-881.

Waldbott, G., A. W. Burgstahler, and H. L. McKinney. 1978. Fluoridation: The Great Dilemma. Colorado Press, Inc., Lawrence. 423 pp.

Weast, R. (Ed.) 1982. The Elements. Handbook of Chemistry and Physics. 62nd Ed. CRC Press, Boca Raton. 2086 pp.

APPENDICES

Appendix A

Raw Data

City[a]	Home	Fruit	Juice	Dry fl	Water	% juice	% dry	% sugar	Type
NO	40	AP	.1072	5.46	.1637	48.27	19.14	16.1	HARD
NO	40	CH	.0541	6.90	.1637	31.27	22.84	18.4	HARD
NO	40	PE	.1121	6.00	.1637	54.09	17.37	13.8	HARD
NO	42	AP	.0775	6.57	.1184	43.44	15.52	11.4	HARD
NO	42	CH	.0622	3.97	.1184	41.43	26.97	21.8	HARD
NO	42	PE	.0655	5.83	.1184	50.71	14.94	12.6	HARD
NO	46	AP	.0694	4.39	.1954	36.33	17.49	16.1	HARD
NO	46	CH	.0578	2.57	.1954	42.68	20.67	19.5	SOFT
NO	46	PE	.0679	5.20	.1954	35.62	18.45	17.2	SOFT
PR	60	AP	.0659	4.33	.1429	41.48	7.55	4.0	NA
PR	60	CH	.0745	1.67	.1429	51.72	16.03	12.6	NA
PR	60	PE	.0659	2.63	.1429	33.92	8.87	5.3	NA
PR	62	AP	.0624	7.42	.1668	25.18	14.68	10.2	SOFT
PR	62	CH	.0932	5.33	.1668	41.69	18.71	13.8	SOFT
PR	62	PE	.0456	2.25	.1668	22.06	17.18	14.9	SOFT
PR	64	AP	.0939	12.13	.1500	54.52	8.33	1.5	NA
PR	64	CH	.0838	2.72	.1500	37.97	23.49	16.1	NA
PR	64	PE	.1088	3.72	.1500	52.43	16.06	10.2	NA
HE	72	AP	.0551	6.12	.1224	41.73	14.41	13.8	NA
HE	72	CH	.1104	7.48	.1224	46.63	36.36	28.3	NA
HE	72	PE	.0936	3.36	.1224	34.65	20.69	16.1	NA
HE	76	AP	.0705	3.10	.1318	33.41	15.38	27.2	HARD
HE	76	CH	.0853	2.38	.1318	43.74	23.46	18.4	HARD
HE	76	PE	.1527	3.51	.1318	36.31	19.32	17.3	HARD
HE	78	AP	.0617	4.31	.1822	33.94	9.78	5.3	SOFT
HE	78	CH	.0832	5.66	.1822	46.04	29.89	24.0	SOFT
HE	78	PE	.0844	3.42	.1822	44.00	15.15	14.9	SOFT

City[a]	Home	Fruit	Juice	Dry fl	Water	% juice	% dry	% sugar	Type
BC	34	AP	.0866	7.79	.0866	46.04	6.25	4.0	HARD
BC	28	CH	.0584	8.31	.0866	29.96	12.31	9.0	HARD
BC	32	PE	.0643	5.03	.0866	28.54	7.75	4.0	HARD
BC	36	AP	.0617	3.82	.0974	22.38	19.43	17.3	SOFT
BC	36	CH	.0622	7.41	.0974	31.91	25.00	20.7	SOFT
BC	36	PE	.0480	3.09	.0974	23.84	20.00	18.4	SOFT
BC	38	AP	.1637	8.28	.0964	43.65	18.85	16.1	HARD
BC	38	CH	.0582	6.36	.1121	34.41	21.52	18.4	SOFT
BC	38	PE	.0480	7.90	.1121	22.65	16.27	14.9	SOFT

[a] NO = North Ogden, PR = Price, HE = Helper, BC = Brigham City.

Home = Identification number.

Fruit = Apricot, cherry, and peach.

Juice = ppm.

Dry fl = ppm.

Water = ppm.

% juice = Percent.

% dry = Percent (percent dry matter of the pulp).

% sugar = Percent.

Type = Water (individuals who submitted water samples reported their water samples as hard or soft).

Appendix B

Quantities of Fluoride in the Food Consumed Daily by Adults in the United States*

Location (United States of America)	Fluoride in food (mg) (exclusive F in drinking water)
Cincinnati, Ohio (0.1)	0.34-0.80
Galesbury, Illinois (2)	0.94-1.16
Ennis, Texas (5-6)	1.32-1.35
Lake Preston, South Dakota (6)	0.99-2.19
Bartlett, Texas (8)	2.33-3.13
O'Donnell, Texas (18)	1.41-1.49
(Average general diet)	0.2+-0.3+

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*Fluorides and Human Health, World Health Organization, Geneva, No. 59, 1970, p. 37.

Appendix B (Continued)

Summary of Estimated Daily Intake of Fluoride from Food and Drinking Water*

Age (years)	Body weight (kg)	From drinking water (mg)	From food (mg)	Total mg	Total (mg/kg of body weight)
1-3	8-16	.390-0.560	.027-.0265	.417-0.825	.026-.103
4-6	13-24	.552-0.745	.036-.3600	.556-1.105	.023-.085
7-9	16-35	.650-0.930	.045-.4500	.695-1.380	.020-.068
10-12	25-54	.810-1.165	.056-.5600	.866-1.725	.016-.069

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*Fluorides and Human Health, World Health Organization, Geneva, No. 59, 1970, p. 37.

Appendix C

Statistical Summary of Data

Variables	Mean	Standard deviation	Standard error
F/City	2.50	1.10	.18
F/Home	54.00	15.95	2.66
F/Fruit	6.00	.82	.13
F/Juice	.78	.26	.44
F/Dry	5.17	2.26	.37
F/H_2O	.13	.33	.55
% juice	38.57	9.28	1.54
% dry	17.67	6.37	1.06
% sugar	14.55	6.34	1.06