The amount of the individual alkaloids present in the smoke compared with that in the leaf is reflected by the percent transfer data. With the UK Reference Cigarette, the high and low extremes for nicotine delivery were 24.2 and 9.8%, respectively. For nornicotine these respective extremes were 15.4 and 7.7%; for anabasine they were 38.2 and 10.2%, and for anatabine the high and low extremes were 8.4 and 2.7%. With the commercial cigarette, percentage of nicotine transferred ranged from 22.8% to 6.7%. The high and low extremes for nornicotine, anabasine, and anatabine were 9.6 and 1.9%, 24.6 and 6.9%, and 6.5 and 1.7%, respectively. The percentage transfer for the individual alkaloids for both cigarettes is similar, with that for the UK Reference Cigarette being slightly higher. The quantities found in the smoke may include a portion synthesized during pyrolysis as well as the portion that is transferred directly from leaf to smoke (Stedman, 1968).

The percentages of nornicotine, anabasine, and anatabine were, of the total minor alkaloid fraction, essentially equal for all smoking treatments. In the UK Reference Cigarette, nornicotine, anabasine, and anatabine accounted for 61, 17, and 20%, respectively, of the total minor alkaloids. In the commercial cigarette their values were 52, 21, and 27%, respectively.

These data indicate that deliveries of TPM, nicotine, nornicotine, anabasine, and anatabine may be altered by changing the smoking pattern. Exposure to the alkaloid fraction can be decreased by decreasing puff volume and/or puff frequency. Changes in the smoking pattern appeared to affect delivery of the individual alkaloids similarly, but the delivery of the minor alkaloids in the mainstream smoke with respect to the delivery of nicotine tended to increase with increased puff frequency. However, transfer of the individual alkaoloids from tobacco to the mainstream was different. Delivery of anabasine and nicotine was greater than delivery of nornicotine and anatabine.

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Effect of Cooking on Selenium Content of Foods

Darla J. Higgs, Virginia C. Morris, and Orville A. Levander*

The effect of cooking on the selenium content of a variety of foodstuffs typically found in the American diet has been studied. Little or no loss of selenium occurred as a result of broiling meats, baking seafoods, frying eggs, or boiling cereals. Dry heating of cereals, however, led to 7 to 23% losses of selenium and boiling two vegetables that contain relatively high amounts of selenium, asparagus and mushrooms, led to 29 and 44% losses of selenium, respectively. It is concluded that most ordinary cooking techniques probably do not result in major losses of selenium from most foods.

Although selenium first assumed public health importance as a result of its toxic properties (Rosenfeld and Beath, 1964), more recent work has shown that the element can also have beneficial nutritional effects when present in the diet in trace amounts (Schwarz and Foltz, 1957; Thompson and Scott, 1970). Aside from preventing a number of diseases in various animals (Hartley and Grant, 1961; Nesheim and Scott, 1961; Schubert *et al.*, 1961), selenium has also been implicated in the etiology of kwashiorkor, a human protein–calorie deficiency disease (Schwarz, 1965) and the sudden death in infants syndrome (Money, 1970). There now exist several reports in the literature which deal with the selenium content of human foods (Morris and Levander, 1970; Oelschlager and Menke, 1969; Schroeder *et al.*, 1970). In two of the above papers attention was called to the fact that cooked or processed foods tended to contain less selenium than raw foods. This was attributed to the well-known instability and volatility of many selenium compounds. However, there have been no published accounts on the effect of cooking *per se* on the selenium content of foods. The purpose of the present study was to investigate the influence of various cooking and heating

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Human Nutrition Research Division, Agricultural Research Service, U.S. Department of Agriculture, Beltsville, Maryland 20705.

Table I. Effect of Drying on Selenium in Cereals

Product[a]	Selenium content, μg/g dry wt	
	Fresh	Dried
Wheat breakfast cereal[b]	0.045	0.027
	0.032	0.032
Oat breakfast cereal[c]	0.51	0.46
	0.50	0.48

[a] Cereals dried overnight at 100°C in electric oven. [b] Wheaties, General Mills, Minneapolis, Minn. [c] Cheerios, General Mills.

Table II. Effect of Boiling on Selenium in Cereals and Grain Products

Product[a]	Selenium content, μg/g dry wt			
	Boiled, min			
	0	5	20	45
Oat cereal[b]	0.078	0.079	0.074	...
	0.077	0.088	0.059	...
Wheat cereal[c]	0.043	0.051	0.053	...
	0.054	0.051	0.053	...
Rice, polished	0.21	...	0.21	...
	0.25	...	0.25	...
Noodles, egg	0.65	...	0.64	0.63
	0.64	...	0.57	0.69

[a] Boiled in quantity of water as recommended on package. [b] Old Fashion Quaker Oats, Quaker Oats Co., Chicago, Ill. [c] Wheatena, Standard Milling Co., Kansas City, Mo.

Table III. Effect of Boiling on Selenium in Vegetables

Product[a]	Selenium content, μg/g dry wt	
	Boiled, min	
	0	20
Mushrooms	1.49	0.79
	1.31	0.76
Asparagus	0.98	0.58
	0.93	0.77

[a] One cup of whole mushroom caps and 2 cups of asparagus tips were cooked in one or 2 cups of distilled water, respectively, in glass beakers covered with loosely fitting watch glasses.

Table IV. Effect of Baking on Selenium in Poultry and Fish

Product[a]	Selenium content, μg/g dry wt		
	Baked, min		
	0	45	60
Chicken light meat	0.47	0.47	
	0.48	0.51	
Flounder	1.46		1.51
	1.30		1.50

[a] Whole chicken breast and whole flounder fillet were both wrapped in aluminum foil and baked in an electric oven at 175°C for the time indicated; end internal temperature of the chicken was 88°C and of the fish was 91°C.

Table V. Effect of Broiling on Selenium in Meat

Product[a]	Selenium content, μg/g dry wt		
	Broiled, min		
	0	20	30
Lamb chops	0.33	0.32	
	0.35	0.35	
Pork chops	0.18		0.17
	0.26		0.23
T-Bone steak	0.71	0.52	
	0.68	0.67	

[a] Whole cuts of meat ($^{1}/_{2}$ in. thick chops, $^{3}/_{4}$ in. thick steak) were cooked in an electric broiler 6 in. from the heating element for the times indicated.

treatments on the selenium content of some foodstuffs typically found in the American diet.

EXPERIMENTAL

Brand name food products were purchased in the Beltsville, Maryland, area from local food stores. Precautions in sampling were taken as described previously (Morris and Levander, 1970). The various heating and cooking treatments are described in the corresponding tables. The selenium content of duplicate samples of a particular raw or treated food was determined by the fluorometric technique of Hoffman *et al.* (1968), as modified by Morris and Levander (1970). Results are expressed on a dry weight basis [in contrast to Morris and Levander (1970)] in order to provide a common basis for comparison among the various treatments.

RESULTS AND DISCUSSION

Heating dry prepared breakfast cereals overnight at 100°C caused a 23 and 7% loss of selenium in the wheat and oat cereals, respectively (Table I). These results agree with those of Moxon and Rhian (1938), who found that corn and wheat grain samples lost 27 and 24% of their selenium after 2 hr of heating at 160°C. Ewan (1971) has also reported that corn dried at 93°C lost about 11% of its selenium. On the other hand, boiling oat or wheat cereals for 5 min caused no losses of selenium, although some Se may have been lost from the oat cereal after 20 min of boiling (Table II). Likewise, boiling rice for 20 min or noodles for 45 min caused no appreciable decline in the selenium content of these food products (Table **II**).

Boiling was found to have a pronounced effect on the selenium content of mushrooms or asparagus (Table III). After 20 min of boiling, mushrooms lost 44% of their Se, whereas asparagus lost 29% of the Se originally present. Challenger and Hayward (1954) found that a deproteinized ethanolic extract of asparagus tips yielded dimethyl sulfide after boiling in alkali. This was thought to be derived from the methylsulfonium derivative of methionine which occurs not only in asparagus but also in cabbage, parsley, turnips, and onion (McRorie *et al.*, 1954). By analogy, we might postulate the formation of the volatile dimethyl selenide from the selenium salt of Se-methylselenomethionine since this conversion is known to occur in cabbage leaves (Lewis *et al.*, 1971).

The data in Table IV show that baking caused no consistent losses of selenium from chicken white meat or flounder. Similarly, broiling had little or no effect on the amounts of Se in a variety of meat products (Table V). The results obtained with broiling are somewhat at variance with those of Heinrich and Kelsey (1954), who found that 10 to 25% of the Se was lost from various tissues after drying. However, this may indicate that usual cooking processes are not drastic enough to bring about the loss of Se from many meat or fish products.

Finally, frying in a Teflon skillet with no shortening added had little effect on the Se content of scrambled eggs, since the raw eggs assayed 0.48 and 0.55 μg of Se/g dry weight, whereas the fried eggs contained 0.48 and 0.51 ppm of Se.

The differences in the lability of the selenium in those two vegetables tried *vs.* the stability of selenium in the meat, seafood, grain, and poultry products tested suggest that there may be a difference in the chemical form of the selenium in these two categories of foodstuffs. Selenium is known to occur in different forms in various plants, depending upon whether the plant is a selenium "accumulator" or a "nonaccumulator" (Peterson and Butler, 1962). The accumulator plants which can take up several hundred parts per million of Se contain Se in the form of free amino acids, whereas Se in the nonaccumulators is found in the protein. Perhaps a similar difference in the chemical form of Se exists between meat, seafoods, etc., *vs.* vegetables; *i.e.*, perhaps in the former foods Se is rather tightly bound in the protein, whereas in the latter foods Se occurs as relatively unstable free selenium compounds that are easily lost upon heating or cooking.

CONCLUSIONS

The results in this study indicate that the major sources of selenium in the American diet (meats, seafoods, eggs, and cereal products) do not lose appreciable amounts of selenium when cooked by most ordinary methods. On the other hand, some vegetables known to contain relatively high levels of sulfur and selenium (asparagus and mushrooms) do lose significant quantities of selenium as a result of cooking. In spite of these losses, however, it appears that most usual cooking practices will not alter the selenium content of the American diet enough to change the statement that "a diet well-balanced in other nutrients is probably also nutritionally adequate with regard to selenium" (Morris and Levander, 1970). Of course, one must still be on the lookout for possible local variation in the Se content of the diet due to geological factors, especially in light of the recent report of Ullrey *et al.* (1971), who found a significant linear correlation between the Se content of feedstuffs and the tissue concentration of Se in animals from several areas of the U.S.

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Effect of Bruising and Aging on the Alcohol-Insoluble Solids of Red Tart Cherries

Richard H. Golder, Sheila M. Levin, George R. Schacterle, and Robert L. Pollack*

Labeled acetate, citrate, and glucose were administered through the stems of carefully picked cherries. The cherries were then bruised and permitted to metabolize for 2 or 24 hr. The bruised cherries contained 1.55% alcohol-insoluble solids at 24 hr, and their unbruised controls contained 1.29%. The change in the alcohol-insoluble solids in the bruised from that of the control was due to increases in the cellulose and lignin fractions, not in the pectin. Glucose incorporation increased from 167 to 250% in all fractions in the controls between the 2- and 24-hr periods, but showed differences of only from 7 to 110% in the bruised cherries with low or no statistical significance. At 2 hr, acetate and citrate levels were above glucose levels, and were affected much less by bruising and aging.

The bruising and aging of Montmorency cherries have been shown to affect the firmness, water-holding capacity, and other characteristics in complex ways, especially in combination with other treatments (Whittenberger, 1952; Hills *et al.*, 1963; Buch *et al.*, 1961). Previous studies, which helped to elucidate some of the biochemical changes underlying these effects, showed that bruising altered respiration and conversion of carbon from acetate and citrate to carbon dioxide (Pollack *et al.*, 1958a,b, 1965) and induced callose formation (Dekazos and Worley, 1967). The studies presented here show further effects of bruising on the overall composition and substrate incorporation into the structural material of the cherries.

EXPERIMENTAL

On three alternate days during the harvest season cherries were harvested, as described previously by Pollack *et al.* (1958b), by cutting the stems gently while supporting the cherries carefully with a cotton pad. The harvested cherries were treated in groups of ten, and the cherries in each group were subsequently combined for homogenization and extraction.

To administer the substrates, 10-μl amounts of the substrates were placed in micro test tubes (about 3 mm × 10 mm). The stems of the cherries were then inserted into the solutions

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Temple University School of Pharmacy, Philadelphia, Pennsylvania 19140.