Fruit and Vegetable Contributions to Dietary Mineral Intake in Human Health and Disease

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In Mar. 1989, the Diet and Health Committee of the National Research Council recommended that persons should increase their consumption of fruits and vegetables such that five or more one-half cup servings of a combination of vegetables and fruits, especially green and yellow vegetables and citrus fruits, be eaten daily (National Research Council, 1989a). The basis for this recommendation was the association of diets high in plant foods (whole-grain cereals and legumes as well as fruits and vegetables) with a lower occurrence of coronary heart disease and cancers of the lung, esophagus, and stomach. The committee pointed out that the biochemical mechanisms responsible for these dietary associations are not fully understood, but could be largely accounted for by the following nutritional characteristics: low saturated (and total) fat and cholesterol content, high complex carbohydrate content, and high content of vitamins A and C.

Relatively little attention has been paid to fruits and vegetables as dietary sources of minerals. This is not particularly surprising since the fruit/vegetable food group is rather poor in many minerals. For example, analytical dietary surveys carried out in Finland (Varo and Koivistoinen, 1980) and in the United States (Pennington et al., 1984) showed that, with the exception of potassium, the fruit/vegetable group contributed 30% or less to the total dietary intake of a variety of minerals (Table 1). It is the purpose of this review to explore further the contribution of fruits and vegetables to dietary mineral intake in human health and disease.

The contribution of fruits and vegetables to the dietary mineral intake of humans

The absolute and relative contributions of fruit and vegetable foods to the dietary intake of various macrominerals are shown in

Table 1. Contribution of fruits and vegetables to dietary intake of minerals.

Mineral	Total dietary intake from fruits and vegetables (%)	
	United States	Finland
Potassium	35	31
Sodium	11	---
Calcium	7	5
Magnesium	24	18
Phosphorus	11	7
Iron	16	13
Zinc	11	7
Copper	30	22
Manganese	21	21
Selenium	1	2
Iodine	3	---

Adapted from Pennington et al. (1984) and Vam and Koivistoinen (1980).

Table 2. Clearly, this food group furnishes appreciable quantities of potassium, which may be important in the control of hypertension. Based on epidemiologic studies and animal experiments, the National Research Council (1989a) concluded that the risk of stroke-related deaths appears to be inversely related to potassium intake and suggested that a diet providing ≈ 3500 mg of potassium daily might contribute to reduced risk of stroke. On the other hand, the Surgeon Generals Report on Nutrition and Health (Dept. of Health and Human Services, 1988) concluded that the evidence linking a reduction in blood pressure with art increased dietary intake of potassium is as yet too preliminary to recommend an increased intake for the general population for the purpose of hypertension control. At any rate, fruits and vegetables are relatively low in sodium, and a diet low in sodium also may be important in controlling blood pressure. Only about one-tenth of the total dietary intake of sodium comes from this food group. Although some leafy green vegetables may be good sources of calcium, the fruit/vegetable group is, in general, a poor source of this element, furnishing <10% of the total dietary intake (Table 2). However, the fruit/vegetable group contributes a fair amount of magnesium, almost one-fourth of the total dietary intake.

The contribution of fruit and vegetable foods to the dietary intake of trace minerals (arbitrarily defined as those minerals with recommended daily intakes in the milligram to tens of milligrams range) is shown in Table 3. This food group is generally a poor source of iron, copper and silicon, furnishing only $\approx 10\%$ of the total dietary intake. On the other hand, fruits and vegetables furnish more than one-fifth the intake of copper and manganese and almost three-fifths of the total boron intake. Boron has recently attracted interest among nutritionists because human studies have shown some connection between this element and the urinary excretion of calcium in postmenopausal women (Nielsen et al., 1987). Additional research is needed to determine whether dietary boron plays any role in bone demineralization and attendant calcium loss in such women.

The contribution of fruit and vegetable foods to the dietary intake of ultratrace minerals (arbitrarily defined as those minerals

having recommended intakes <1 mg-day⁻¹) is shown in Table 4. Fruits and vegetables contribute relatively little selenium or molybdenum to the total dietary intake (although vegetables from seleniferous areas can be quite rich in selenium, see next section). Fruits and vegetables can, however, furnish about one-fifth of the total dietary intake of chromium and arsenic and one-third of the supply of nickel. Roles for the latter three ultratrace elements in human nutrition are presumed, but additional research is needed to establish their Practical importance.

The contribution of fruit and vegetable foods to the dietary intake of toxic minerals is shown in Table 5. this food group can contribute about one-third of the total intake of cadmium and lead, heavy metals that have long been of ecological concern.

Vegetables as a vehicle for increasing the selenium content of the food supply

Selenium deficiency has been shown to be a predisposing condition in the etiology of Keshan disease, a cardiomyopathy affecting primarily children and women of child-bearing age in China (Yang et al., 1988). Lack of dietary selenium also may be involved in the cause of Kashin-Beck disease, an endemic juvenile osteoarthritis that occurs along the Sine-Siberian border (Levander, 1987). Some animal experiments and epidemiologic studies suggest that selenium may play a protective role against certain human cancers, although the relationship between dietary selenium intake and the incidence of cancer remains an open question (Willet and Stampfer, 1988).

Several different techniques have been used in China to increase the selenium intake as a way of preventing Keshan disease: Selenium-containing tablets have been distributed field crops have been sprayed with selenium, and table salt has been fortified with selenium. In Finland, selenium has been added to fertilizers used on grains and forages since 1984, and the serum selenium level in the general population there has increased by $\approx 50\%$ (Varo et al., 1988).

Should it be considered desirable to increase the dietary selenium intake in other countries, vegetables could be an important com-

Table 2. Contribution of fruit and vegetables to dietary intake for macrominerals.

Macromineral	Daily dietary intake (mg)			Recommended intake (mg/day)
	Fruit/vegetable	Total	Percent of total	
Potassium	1188	3394	35	1600-3500
Sodium	536	4875	11	500-2400
Calcium	80	1146	7	800
Phosphorus	190	1727	11	800
Magnesium	82	340	24	350

Recalculated from Pennington et al. (1984); recommended intakes based on adult male values give by the National Research Council (1989b).

Table 3. Contribution of fruit and vegetable foods to dietary intake of trace minerals.

Trace mineral	Daily dietary intake (mg)			Recommended intake (mg/day)
	Fruit/vegetable	Total	Percent of total	
Iron	2.5	19	13	10
Zinc	1.1	16	7	15
Copper	0.37	1.7	22	1.5-3
Manganese	1.3	6.1	21	2-5
Silicon	3.7	29	13	5-20?
Boron	1.0	1.7	59	1?

Recalculated from Varo and Koivisto (1980); recommended intakes for Fe, Zn, Cu, and Mn based on adult male values given by the National Research Council (1989b); others as suggested by Nielsen (1990).

Table 4. Contribution of fruit and vegetable foods to dietary intake of ultratrace minerals.

Ultratrace mineral	Daily dietary intake (μ g)			Recommended intake (μ g/day)
	Fruit/vegetable	Total	Percent of total	
Selenium	0.5	30	2	70
Chromium	6.8	29	23	50-200
Molybdenum	15	120	13	75-250
Nickel	44	130	34	<150?
Arsenic	12	58	21	15?

Recalculated from Varo and Koivisto (1980); recommended intakes for Se, Cu, and Mo based on adult male values given by the National Research Council (1989b); others as suggested by Nielsen (1990).

Table 5. Contribution of fruit and vegetable foods to dietary intake of toxic minerals.

Toxic mineral	Daily dietary intake (μ g)			Recommended max. intake (μ g/day)
	Fruit/vegetable	Total	Percent of total	
Mercury	0.3	5.7	5	43
Cadmium	3.8	13	29	57-71
Lead	22	66	33	430

Recalculated from Varo and Koivisto (1980); recommended maximum intakes recalculated from provisional weekly intakes established by FAO/WHO (1972).

ponent of such a strategy. Although fruits and vegetables usually contribute little to the total dietary intake of selenium (normally 5% or less) the selenium content of plant foods varies considerably depending on the amount of selenium available for uptake from the soil. A variety of vegetables (potato, tomato, carrots, cabbage, and onion) grown in seleniferous soils contained 2 to 3 orders of magnitude more selenium than those grown in nonseleniferous soils (Levander, 1976). Therefore, the potential for increasing dietary selenium intake by the selenization of vegetables is there. should the scientific evidence warrant taking such a step.

Although selenium has been shown to have beneficial effects on human health in some cases, such as Keshan disease, the desirability of increasing the selenium content of the food supply in general is still uncertain. For example, attempts to enhance the antineoplastic properties of brussels sprouts against chemically induced cancer in rats by raising the selenium content of this vegetable have been unsuccessful (Stoewsand et al., 1989). Furthermore, under some experimental conditions, elevated intakes of selenium actually increased rather than decreased the incidence of chemically induced cancer in laboratory animals (Nutrition Reviews, 1989). Thus, in certain situations selenium may be not only ineffective, but also harmful. Public health authorities in various countries will have to use the proper degree of caution when deciding whether or not to add selenium to their national food supplies.

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