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Zinc and Selenium Levels in Selected and Ethnic/Regional Foods

Ira Wolinsky,* Helen W. Lane, Doris C. Warren, and Brenda S. Whaley

Zinc and/or selenium contents of 73 foods, many of them regional favorites, were reported. Trace element concentrations of foods were determined on homogenates and expressed in terms of portion size (common serving size) and 100 g wet weight. Zinc analysis was performed by flame atomic absorption spectrophotometry; selenium was monitored spectrofluorometrically. On a 100-g wet-weight basis, some of the better sources of zinc included cheddar and Swiss cheeses, wheat crackers, and granola bar; among ethnic/regional foods, beef burrito, chili, cornbread, enchiladas, okra, shrimp gumbo, pecan pie, and turnip greens provided from 0.8 to 1.5 mg of zinc/portion size. Among the best sources of selenium were foods prepared with milk or milk products and local favorites including burrito, chicken enchilada, Gulf Coast red drum fish, shrimp gumbo, and taco. No foods analyzed were outstanding zinc sources, i.e. a food(s) that would provide a significant amount of the daily zinc requirement; in contrast, several foods were outstanding selenium sources.

In order to perform certain nutritional metabolic studies, conduct and evaluate nutritional surveys of various populations, treat certain nutritional disorders in clinical situations, and educate the general public as to nutrient content of their diets, it is necessary to determine nutrient contents of foods. Food nutrient data may be found in printed tables of food composition and/or entered into computer-stored nutrient data bases (Hertzler and Hoover, 1977; Hoover, 1983, 1984) and used, increasingly and effectively, in sundry ways including cost-optimized menu planning, menu nutrient analysis of client intake data, and research.

In our laboratories, studies employing diet histories are being performed (Lane et al., 1982, 1983a–c, 1984; Hunt et al., 1984). We recognized the need for valid and accurate values for the trace-element concentrations of certain foods, many of them regional favorites commonly consumed by southern white, black, and hispanic populations. In particular, the adequacy of zinc and selenium in the diets of Americans concerns health professionals, including nutritionists (Burch et al., 1975; Lane et al., 1983a–c).

EXPERIMENTAL SECTION

The concentrations of trace elements were determined only for foods purchased or prepared locally (Houston). Foods selected were those common in this area and/or the ones used by subjects in our studies (Lane et al., 1983a–c, 1984).

Canned foods or prepared boiled foods were drained so that analyses were completed only on the solid fraction; the leachates were not analyzed. For draining, a stainless steel kitchen sieve (size 14) was used until no further drainage was observed, about 10 min. Prepared foods were cooked in accordance with manufacturer's instructions. For each food, a portion size (i.e., common serving size) was measured and weighed. Portion sizes were based on solids after draining (where applicable) and on quantities typically consumed in our studies (Lane et al., 1983a–c, 1984). Either a portion size of homogeneous items or the entire food item was homogenized, and duplicate or triplicate aliquot samples of this homogenate were taken for analysis. All glass and plastic containers were acid washed; all chemicals, containers, and water were monitored routinely for zinc and selenium contamination (Varian, 1979). Both U.S. National Bureau of Standards (wheat or bovine liver) and Fisher Co. reference standards were used routinely for instrument calibration and method validation. For selenium, the result (ppm) for the National Bureau of Standards bovine liver standard (1.1 ± 0.05) was 1.0 ± 0.02; for zinc (10.6 ± 1.0) it was 10.73 ± 0.66. Trace-metal concentrations were expressed in terms of portion size and 100 g of wet weight.

For zinc determinations, weighed portions of homogenized or powdered foods were dried for 4 h at 100 °C in a muffle furnace, then the temperature was gradually raised to 550 °C, and the samples were ashed for 24 h. The ash was solubilized in 1 N HNO_3 and diluted to a final volume of 25 mL with the same diluent. If necessary, ash solubilization was enhanced by using a larger volume of 1 N HNO_3 and/or solutions were warmed slightly under warm running tap water. Zinc concentrations were measured by flame atomic absorption spectrophotometry (Varian AA-275; Varian Associates, Inc., Palo Alto, CA) at 213.5 nm, with a 1-s integration time (Varian, 1979; Lane et al., 1982).

Details of selenium determination (including wet ash preparation and spectrofluorometric assay) were reported previously from this laboratory (Lane et al., 1983a).

RESULTS AND DISCUSSION

Zinc and selenium levels of food items are given in Table I. On a wet-weight basis, some of the better sources of zinc from common foods analyzed included cheddar and Swiss cheeses, wheat crackers, and granola bar. Among the ethnic/regional foods, beef burrito, chili, cornbread, enchilidas, okra, shrimp gumbo, pecan pie, and turnip greens provided from 0.8 to 1.5 mg of zinc/portion size. The enchiladas provided an example of the variability of zinc content within a similar product, and these differences reflect the high zinc content of their fillings since meats and dairy products are the food groups that provide the richest zinc sources (Freeland-Graves et al., 1980; Lawler and Klevay, 1984). Generally, for those food items previously evaluated for zinc content by other laboratories (Murphy et al., 1975; Freeland and Cousins, 1976; Freeland-Graves et al., 1980; Truesdell et al., 1984; Lawler and Klevay, 1984) our values were quite comparable. These include cheddar cheese, wheat crackers, canned beets, diet cola, lima beans, green pepper (jalapeno in our study), and corn chips. Except for chili con carne, there are no literature zinc values for any ethnic/regional foods popular in

Department of Human Development, University of Houston, Houston, Texas 77004 (I.W.), Department of Nutrition and Foods and Alabama Agricultural Experiment Station, Auburn University, Auburn, Alabama 36830 (H.W.L.), and Department of Chemistry, Houston Baptist University, Houston, Texas 77074 (D.C.W., B.S.W.).

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Table I Zinc and Selenium Levels in Selected and Ethnic/Regional Foods

food item	portion		moisture, %	Zn concentration[a]		Se concentration[a]	
	g	common measure		mg/100 g wet weight	mg/portion size	µg/100 g wet weight	µg/portion size
alcoholic drinks							
Pina Colada, mix, rum	139	1/4 cup	95	0.084	0.12	0.3	0.42
Margarita, mix, vodka	131	1/4 cup	88	0.088	0.12	–	–
avocado, seed removed	120	1.2 medium	65	–	–	1.0	1.20
bean, lima, baby, frozen, cooked and cooled	80	1/2 cup	72	0.753	0.60	1.0	0.80
beans, pinto, canned, cooked	84	3 oz.	75	0.263	0.22	–	–
beans, refried, frozen dinner	84	3 oz.	61	0.660	0.55	3.0	2.52
beef steak, prepared as chicken-fried steak with gravy[b]	84	3 oz.	54	1.463	1.23	10.0	8.40
beef stew, canned	258	1 cup	82	1.079	2.78	5.0	12.90
beets, canned, sliced	170	1 cup	94	0.340	0.58	2.0	3.40
beverages, cola, carbonated	342	12 fluid oz.	99	0.005	0.02	0.2	0.68
bread, winter, whole wheat ground	23	1 slice	30	–	–	36.0	8.28
burrito, beef and bean filling, frozen dinner	140	5 oz.	47	0.988	1.38	15.0	21.00
cereal, raisin bran	42	1 cup	13	1.250	0.53	–	–
cheese, cheddar, medium aged, Longhorn	28	1 oz.	37	3.555	1.00	8.0	2.24
cheese, cottage, regular curd	224	1 cup	81	–	–	9.0	20.16
cheese, Swiss	28	1 oz.	38	2.727	0.76	3.0	0.84
cheesecake, homemade, with cream cheese and graham cracker crust	40	1 slice (2 in. × 4 in. × 1 1/2 in.)	43	0.765	0.31	8.0	3.20
chili, without beans, canned	230	1 cup	73	0.380	0.87	–	–
chilies, canned	14	1/2 oz.	92	–	–	2.0	0.28
chips							
corn	40	1 cup	5	1.614	0.65	4.0	1.60
tortilla, nacho cheese flavored	40	1 cup	6	0.954	0.38	7.0	2.80
potato	20	1 cup	4	1.598	0.32	8.0	1.60
coleslaw, carrot and raisin, mayonnaise dressing[b]	126	1 cup	76	0.277	0.33	ND	ND
cornbread, southern style[b]	78	1 slice (2″ × 2″)	74	0.977	0.76	11.0	8.58
cornmeal							
masa harina	37	1 tbsp	8	–	–	15.0	5.55
masa trigo	37	1 tbsp	10	–	–	11.0	4.07
crackers, wheat	17	5	3	2.459	0.42	9.0	1.53
cream, imitation, nondairy powder	3	1 tsp	4	0.172	0.005	3.0	0.09
dip, guacamole	35	2 tbsp	77	0.137	0.05	1.0	0.35
eggs, scrambled egg mix[b]	42	1.5 oz.	84	–	–	12.0	5.04
eggplant, canned	200	1 cup	96	1.039	2.08	–	–
enchilada, beef, chili gravy, frozen dinner	134	1/2 cup	69	0.670	0.90	2.0	2.68
enchilada, cheese, chili gravy, frozen dinner	132	1/2 cup	69	0.635	0.84	–	–
enchilada, chicken frozen dinner	138	1/2 cup	65	1.054	1.45	11.0	15.18
fish, red drum Gulf Coast, frozen	84	3 oz.	81	0.364	0.31	37.0	31.08
fruit cocktail, heavy syrup, canned	256	1 cup	86	0.413	1.05	–	–
granola bar, oats and honey	22	1 bar	0.03	2.806	0.62	13.0	2.86
ice cream, chocolate	133	1 cup	61	–	–	7.0	9.31
jelly, grape	20	1 tbsp	42	0.342	0.07	–	–
macroni and cheese, mix, cooked	240	1 cup	60	0.765	1.84	16.0	38.40
milk, whole, chocolate	240	1 cup	87	–	–	9.0	21.60
milkshake, chocolate[b]	240	1 cup	82	–	–	2.0	4.80
milkshake, strawberry[b]	240	1 cup	80	–	–	3.0	7.20
nachos, homemade with tortilla chips, cheddar cheese, and jalapeno pepper	22	5	95	1.614	0.35	7.0	1.54
noodles, medium, egg enriched, boiled	31	1/4 cup	60	0.952	0.30	18.0	5.58
nopalito (chopped cactus shoots dish)	68	1 medium	32	–	–	20.0	1.36
okra, canned	180	1 cup	95	0.458	0.82	–	–
okra, gumbo, creole style, canned	148	1/2 cup	93	0.346	0.51	0.1	0.15
olives, Spanish	15	5 medium	68	0.292	0.04	0.1	0.02
orange juice, frozen concentrate diluted to recipe	124	1/2 cup	94	0.046	0.06	2.0	2.50
peanut bar cookie	43	1 bar	3	1.766	0.76	ND	ND
pepper, jalapeno	23	2 tbsp	91	0.098	0.02	0.4	0.09
pie, pecan, frozen	173	1 slice[b]	77	0.859	1.49	0.2	3.46
pizza, sausage, frozen	64	1 slice[c]	50	0.690	0.44	–	–
plaintain, raw	153	1 medium	62	–	–	2.0	3.06
plums, raw	20	1 medium	85	0.150	0.03	–	–
rice, Mexican, frozen, white rice with tomato sauce, red and green peppers, onions	108	1/2 cup	77	0.239	0.26	5.0	5.40
shrimp, gumbo, frozen, with white rice and peppers	147	1/2 cup	78	0.705	1.04	18.0	26.46
sauces							
picante	33	2 tbsp	91	0.211	0.07	1.0	0.33
mole (chilies and unsweetened chocolate paste)	38	1 tbsp	25	–	–	7.0	2.66
sugar substitutes							
saccharine	1	1 packet	11	0.079	0.001	2.0	0.02
aspartame	1	1 packet	12	ND	ND	ND	ND

Table I (Continued)

food item	portion g	portion common measure	moisture, %	Zn concentration[a] mg/100 g wet weight	Zn concentration[a] mg/portion size	Se concentration[a] μg/100 g wet weight	Se concentration[a] μg/portion size
taco, ground beef, sauce, lettuce, tomato, cheddar cheese filling in a corn tortilla[b]	241	1 medium	57	–	–	1.0	4.10
tomatillo, raw	68	1 medium	24	–	–	4.0	2.72
tortilla, corn	33	1 of 6-in. diameter	31	1.192	0.39	3.0	0.99
tortilla, flour	31	1 of 7-in. diameter	19	0.534	0.17	7.0	2.17
turnip greens, canned	200	1 cup	91	0.652	1.30	–	–
yams, baked, with skin	41	$^1/_2$ cup	82	0.417	0.17	2.0	0.82
yams, baked, without skin	41	$^1/_2$ cup	71	0.373	0.15	ND	ND
yogurt, lemon	183	6 fluid oz.	97	0.154	0.28	–	–
zucchini squash, fresh boiled	58	$^1/_4$ cup	95	0.331	0.19	1.0	0.58

[a] Dashes in the table indicate where no analysis was performed. ND = not detected; the concentrations were below the limit of detection: Se, <0.01 μg/g of sample; Zn, <1.0 μg/g of sample. All foods were store bought unless indicated as homemade or purchased from commercial food services. Store-bought items were used raw or prepared according to recipe. [b] Purchased from commercial food services. [c] One-fourth of $8^1/_2$-in.-diameter pie. [d] One-fourth of 7-in.-diameter pie.

this area. Freeland and Cousins (1976) reported 1.63 mg/100 g wet weight for chili whereas our value for chili, without beans, was only 0.38 mg/100 g wet weight. Hypothetically, differences may be explained by the different amounts of beans in the recipes and/or the method of preparation and/or sample preparation of the food items in Freeland and Cousins' laboratory. The zinc values presented in Table I differed considerably for some foods previously measured by others (Freeland and Cousins, 1976; Truesdell et al., 1984). Their values (milligrams/100 g wet weight) were as follows: nondairy artificial creamer (0.04), pizza (1.22), potato chips (0.81), cooked zucchini squash (0.18), pinto beans (1.30), and Swiss cheese (4.10). The differences may be due to differing modes of preparation, source of food items, and sampling methods.

On a portion size basis, among the best sources of selenium were foods prepared with milk or milk products: cottage cheese, chocolate ice cream, whole milk, and macaroni and cheese. Among regional favorites, the best sources of selenium were burrito, chicken enchilada, Gulf Coast red drum fish, shrimp gumbo, and taco. The values for selenium contents compare favorably to other laboratories' analyses (Morris and Levander, 1970; Thorn et al., 1978) for identical or similar foods; these include banana (plaintain in our study), saccharine-based sugar substitute, cream substitute, and cheddar cheese. In this study the selenium contents for Mexican rice was similar to that previously reported by our laboratory (Lane et al., 1983a) for unenriched white rice (0.065 μg/g wet weight). Some of our values for selenium differed from those reported by Morris and Levander (1970). They reported (micrograms/100 g wet weight) 62 for egg noodles, 0.5 for saccharine sugar substitute, and 10 for Swiss cheese. Again, the differences may be due to moisture content (e.g., egg noodles) as well as the selenium content of ingredients. Levander (1975) showed that the mean selenium content of seafoods exceeded that of meats, cereal products, vegetables, and fruits. In the present study, on a wet-weight basis, Gulf Coast drum fish proved to be the best selenium source; its value was similar to that for flounder fillet (34) and cod fillet (47) previously reported in the literature (Morris and Levander, 1970; Lunde, 1970). An interesting finding in this study was the observation that the selenium content of yams was entirely within the skin portion; this was not the case for zinc.

A prominent observation from this study in that there were no foods analyzed that were outstanding zinc sources, i.e. a food(s) that would provide a significant amount of the daily zinc requirement. In contrast, there were several foods that were outstanding selenium sources.

When data for zinc and selenium contents of food items reported herein are evaluated, a word of caution is necessary since the trace-element level may have little relation to the actual bioavailability of the element. Several factors can influence the absorption and retention of zinc, among them phytate, fiber, and trace-element contents of the food (Prasad, 1979; Solomons, 1982; Hurley et al., 1983). Other environmental and endogenous factors can affect zinc content of foods (Prasad, 1979) such as cooking, processing, genetic influences, and age of animal or plant. Although not as well documented as for zinc, one must assume that similar factors operate to affect the availability and content of selenium in foods: Allaway (1973) reviews factors that may influence the uptake of selenium by plants; Higgs et al. (1972) and Tanticharoenkiat et al. (1988) report the effect of cooking on selenium content; Morris and Levander (1970) has commented that selenium levels in foods may vary by geographical area and processing methods.

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Investigation of the Main Components in Insect-Active Dill Seed Extract

Helen C. F. Su* and Robert Horvat

In previous studies, dill (*Anethum graveolens* L.) seed acetone extract was biologically active against several species of stored-product insects and also gave long-lasting repellency against the confused flour beetle, *Tribolium confusum* Jacquelin du Val. The extract was analyzed by HPLC monitored with a UV detector at various wavelengths. The major components were isolated, purified by TLC and HPLC techniques, and identified as 2-methyl-5-(1-methylethenyl)-2-cyclohexen-1-one (*d*-carvone) and 4,5-dimethoxy-6-(2-propenyl)-1,3-benzodioxole (dillapiol).

Anethum graveolens L. (dill) of the Apiaceae family is a common herb. Its leaves and seed are used as a condiment in cooking and also in pickling. The composition and characteristics of the dill plant and its essential oil (from leaves and seeds) have been investigated extensively (Baslas and Baslas, 1972; Salzer, 1975; Stahl and Herting, 1976; Herrmann, 1978; Teuber and Herrmann, 1978; Koedam et al., 1979; Henry, 1982; Huopalahti and Linko, 1983; Porter et al., 1983). The insecticidal properties and the synergistic activities of dill plants were reported by Hartzell (1944) and Lichtenstein et al. (1974).

The effects of the lyophilized dill seed acetone extract to several species of stored-product insects were reported (Su, 1985, 1987). We now report the isolation and identification of the main components from the insect-active extract of dill seed by chromatographic and spectral methods.

MATERIALS AND METHODS

Preparation of Dill Seed Extract. The extract of dill seed was prepared by acetone extraction of the pulverized seed powder at 40–50 °C as described by Su (1985). The extract was lyophilized at 0–5 °C to obtain a light brown syrupy material.

High-Performance Liquid Chromatographic Study of Dill Seed Extract. A Waters Associates Model ALC/GPC 244 HPLC equipped with a Model 6000A pump, a U6K injector, and a Model 440 UV detector with a 300 × 7.8 mm (i.d.) μBondapak C_{18} column (octadecyltrichlorosilane covalently bonded to 10-μm μPorasil packing) was used. Methanol–water (70:30, v/v, degassed) was used as the eluting solvent. The effluent was monitored at 254, 280, 313, 340, 365, and 405 nm, and the response (1.0 AUFS) was recorded on a Waters Associates M730 Data Module recorder.

Thin-Layer Chromatographic (TLC) Separation of *d*-Carvone for Infrared (IR) Study. For TLC separation, Brinkman EM reagent, precoated silica gel F_{254}, 0.25-mm, 20 × 20 cm chromatoplates were used. About 3–4 mg of the dill extract was applied to each plate in a straight line 2.5 cm above the lower edge to a distance of 3 cm from the right edge. A spot of authentic *d*-carvone was applied at the same height, 1.5 cm from the right edge. A total of 15 plates was prepared. Each plate was developed twice in benzene–chloroform (90:10, v/v) and then examined under UV at 254 nm. The bands that corresponded to the *d*-carvone spots were collected and eluted with methanol. The methanol extract was concentrated slowly under reduced pressure, and the resulting liquid was used for the IR study.

Instrumental Analyses. A Du Pont Model 21-490B mass spectrometer was used with a direct-insertion probe at a temperature of 75–250 °C. Other conditions used were as follows: ion source temperature, 150 °C; ionizing voltage, 70 eV; ion source pressure, 4×10^{-6} Torr; scan rate, 100 s/decade from 15 to 500 amu.

GLC–MS analyses were performed with a Perkin-Elmer Model 300 GLC that was connected by an effluent splitter to a Du Pont Model 21-490B mass spectrometer. The GLC column used was a 50 m × 0.32 mm fused silica capillary column coated with SE-54 with He at 0.6 kg/cm^2 pressure as the carrier gas. Oven temperature was programmed from 50 to 215 °C at 4 °C/min. Mass spectrometer con-

Stored-Product Insects Research and Development Laboratory, U.S. Department of Agriculture—Agricultural Research Service, Savannah, Georgia 31403 (H.C.F.S.), and Richard B. Russell Agricultural Research Center, U.S. Department of Agriculture—Agricultural Research Service, Athens, Georgia 30604 (R.H.).