Iron, Zinc, and Copper: Contents in Common Chilean Foods and Daily Intakes in Santiago, Chile

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OBJECTIVES: We determined the iron (Fe), zinc (Zn), and copper (Cu) contents of common Chilean foods and assessed the intakes of these elements in a population living in Santiago, Chile.

METHODS: We selected foods most consumed by a Chilean population ($n = 108$). We performed wet digestion of the sample by using nitric, perchloric, and sulfuric acids. Fe, Zn, and Cu were determined by atomic absorption spectrophotometry. Fe, Zn, and Cu intakes were evaluated by a dietary survey (24-h recall questionnaire for 4 non-consecutive days) in a representative sample of the population of Santiago, Chile ($n = 252$ subjects).

RESULTS: Fe intakes (mg/d) were 7.8 ± 9.6 (in infants), 8.1 ± 5.3 (in 1- to 10-y-olds), 15.1 ± 7.3 (11- to 19-y-old males), 9.5 ± 4.3 (11- to 19-y-old females), 13.5 ± 6.5 (20- to 64-y-old males), 9.1 ± 3.9 (20- to 64-y-old females), 11.4 ± 4.9 (≥65-y-old males), and 11.3 ± 5.0 (≥65-y-old females). Zn intakes (mg/d) were 3.8 ± 1.8 (infants), 6.2 ± 3.1 (1- to 10-y-old subjects), 8.9 ± 4.1 (11- to 19-y-old males), 5.7 ± 2.0 (11- to 19-y-old females), 7.6 ± 3.4 (20- to 64-y-old males), 6.4 ± 3.5 (20- to 64-y-old females), 6.6 ± 2.9 (≥65-y-old males), and 6.9 ± 2.4 (≥65-y-old females). Cu intakes (mg/d) were 0.5 ± 0.3 (infants), 0.8 ± 0.5 (1- to 10-y-old subjects), 1.4 ± 0.7 (11- to 19-y-old males), 1.2 ± 0.3 (11- to 19-y-old females), 0.9 ± 0.4 (20- to 64-y-old males), 1.0 ± 0.4 (20- to 64-y-old females), 1.1 ± 0.3 (≥65-y-old males), and 0.9 ± 0.4 (≥65-y-old females).

CONCLUSIONS: Fe deficiency was greater in infants and women of fertile age. All age and sex groups had a high risk of Zn deficiency, whereas adults of both sexes had a moderate increased risk of Cu deficiency.

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KEY WORDS: iron, zinc, copper, human, deficiency, foods, composition

INTRODUCTION

Iron (Fe), zinc (Zn), and copper (Cu) are involved in the function of several enzymes and are essential for maintaining health throughout life.[1,2] Trace mineral deficiencies constitute the largest nutrition and health problem that affects populations in developed and developing countries. There is an increasing recognition of the coexistence of multiple micronutrient deficiencies in developing countries. Fe deficiency is the most prevalent single nutritional deficiency in the world and is the main cause of anemia in infants, children, adolescents, and women of childbearing age.[3] Zn deficiency may be widespread in developing countries, but it is under-recognized due to lack of sensitive biomarkers of Zn status.[4] Cu deficiency is less frequent and has been described mainly in premature infants and children recovering from malnutrition.[5]

Food normally accounts for a high proportion of macro and trace mineral intakes in adults and children.[4] Mineral intakes and their interactions with other components of the diet influence the susceptibility to dietary trace mineral deficiency or excess.[1] Concentrations of Fe, Zn, and Cu in foods vary depending on inherent (varieties, maturity, genetics, and age) and environmental (soil, geographic location, season, water source, and use of fertilizers) conditions of plants and animals and on methods of handling, processing, and cooking.[1,3,6] As for most developing countries, the contents of essential minerals in Chilean foods are not known. In addition, there is scarce information on Fe, Zn, and Cu intakes in our population. Further, in the studies available, foreign food composition tables have been used to calculate the intakes of these trace minerals.

The purpose of the study was to assess the Fe, Zn, and Cu intakes in a population living in Santiago (Chile) and to generate information about Fe, Zn, and Cu contents in foods frequently consumed by our population. This information is crucial to assess the risks of deficiency and toxicity at different ages and in both sexes.

MATERIALS AND METHODS

Food Composition Analysis

Fe, Zn, and Cu contents of 108 food items were measured. Food selection was based mainly on food-frequency consumption by the Chilean population. The main source of information was data obtained from the study's dietary survey. In addition, native foods were included, even if they were not listed in the high-frequency consumption list, because there was no information with regard to their Fe, Cu, and Zn contents. Sampling procedure followed the guidelines of the International Network of Food Data Systems (INFOODS).[7,8] Sample size was determined according to Cochran's equation[7] using coefficients of variation calculated from

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data published by Pennington et al.[6] Criteria for calculating the number of samples to be analyzed were as follows: $t = 1.96$ ($\alpha = 0.05$) and $r = 0.1$, 0.2, and 0.3 when the reported coefficients of variation were ≤33%, >33% to ≤66% and >66%, respectively. In addition, a maximum of 54 samples was collected and analyzed even when the calculated number was larger than 54. No composite samples were prepared. A sampling plan was designed for each food item. Depending on the food, up to 10 brands or varieties were collected. The food items were purchased at commercial settings such as supermarkets or grocery stores in the Santiago Metropolitan Region. Foods having a seasonal production were analyzed in their respective seasons. Different sources such as sales database of a supermarket representing the middle-class population in the metropolitan region, weekly technical bulletins from the Office of Agricultural Planning, or interviews with managers from the major city markets were used to define sampling distribution according to commercial brands or varieties. The purchased food items were immediately taken to the laboratory. Food items such as vegetables, fruits, meats, fish, and shellfish that were not prepackaged when purchased were packed by us in double polyethylene bags before being transported. The remaining food items were kept in their original packages. Food items were processed in a laboratory area class 10,000 according to the US Federal Standard 209-E. All food items, fresh and processed, were analyzed without further preparation. With the exception of green beans, legumes were dry mature seeds. Nuts such as almonds, peanuts, and walnuts were dry and without shell. Legumes, vegetables, and fruits were carefully washed with distilled, deionized water. Fruits, fish, shellfish, roots or tubers, and poultry were peeled with a polypropylene knife. All cuts were done on a polypropylene table. Meats, dairy products, and eggs were processed for analysis as purchased. All food handling was done with hands covered by non-powdered latex gloves. The sample preparation protocol did not include the recording of the refuse weight. One to five grams of each nonhomogenized food item was weighed, according to its estimated theoretical Cu content, and weights of the selected portions were recorded. Wet digestion of the sample was performed with nitric, perchloric, and sulfuric acids.[9] Fe, Zn, and Cu were determined by atomic absorption spectrophotometry (model 2280, Perkin Elmer, Norwalk, CT, USA). The lower detection limit for Fe, Zn, and Cu was 0.1 μg/g. The objective of the study did not include the analysis of other food components.

Each selected food item was considered as one batch. For each batch, the following control samples were simultaneously analyzed: analytical blanks, enriched samples (spiked), and certified reference food items (bovine liver, non-fat dry milk, or wheat flour; National Institute of Standards and Technology, Gaithersburg, MD, US). Control samples were measured on a daily basis. All control analyses and one sample per batch were done in duplicate. Control charts were kept to ensure minimization of analytical error as a source of variability. Recoveries were within acceptable values (mean recoveries for Fe, Zn, and Cu ranged from 96% to 102%), and good agreement was found between certified and analyzed values. The coefficient of variation for multiple analyses of the standard reference materials ranged from 7.1% to 10.4% for Fe, Zn, and Cu. The relative difference between duplicate samples was 3.1%.

Dietary Survey

This was a one-time survey. The sample was designed to be statistically representative of the population of Santiago in 1997, consisting of 5 173 158 people living in 1 131 142 households. Sampling procedures are described fully elsewhere.[10] The sample was sufficiently large to represent the socioeconomic levels of Chilean society and the following age groups (with an absolute error of 6.2%): younger than 1-y-old, 1–10-y-olds, 11–19-y-olds, 20-64-y-olds, and older than 64-y-old. The absolute error designed for the sample determined a sample size of 250 subjects. Because infants are more sensitive to trace mineral deficiency and excess, additional subjects younger than 1 y were included.

After informed written consent was obtained, a 24-h recall questionnaire for each selected individual was filled out by a trained research dietitian on 4 non-consecutive days (two in spring and summer and two in fall and winter) between December 1997 and December 1998. Intake of each food item was calculated per serving portion. Food models and common household measuring utensils were used to estimate portion sizes. Serving portions were based on information published by Gattas and Aguayo.[11] Each serving portion was converted to grams according to a home measure table.[11] Fe, Zn, and Cu intakes were calculated by applying the information on trace mineral composition obtained in this study. The US Department of Agriculture food composition table was used for those foods for which there was no information of trace mineral content in the data compiled by Gatas and Aguayo.[12] Mixed foods were divided into constituent parts to determine their contribution to Fe, Zn, and Cu intakes.

To assess the magnitude of inadequate intakes of Fe, Zn, and Cu, we used the estimated average requirement (EAR) cutoff points proposed by the US Institute of Medicine.[1]

The study was reviewed by and was in agreement with the standards set by the Institute of Nutrition and Food Technology's Ethics Committee on Human Research.

Statistical Analyses

All continuous data were expressed as mean ± standard deviation. Statistical analyses were performed with Statistica 4.5 for Windows (StatSoft, Tulsa, OK, USA). The *t* test for independent samples was used for comparison between two groups. These pairwise comparisons were confirmed by non-parametric analysis using the Mann-Whitney *U* test to ensure that any observed differences were not attributable to differences in population distribution. Categorical variables were tested for statistical significance with the chi-square test or Fisher's exact test. $P \leq 0.05$ was considered statistically significant.

RESULTS

The Fe, Z, and Cu contents of the analyzed food items, including mean values, standard deviations, and coefficients of variation, are presented in Table I.

A total of 252 subjects completed the dietary survey. There were statistically significant differences in Fe, Zn, and Cu intakes by sex at ages 11 to 19 y and 20 to 64 y. Men had higher Fe intake at ages 11 to 19 y and 20 to 64 y, higher Zn and Cu intakes at ages 11 to 19 y, and lower Cu intake at ages 20 to 64 y (Table II). Nutrient density was not statistically significant different by sex, except for Cu density at ages 20 to 64 y (Table III).

Percentages of subjects with Fe, Zn, and Cu intakes below the EARs are shown in Table IV. A high proportion of infants and women between the ages of 11 and 64 y had Fe intakes less than EARs. A high frequency of Zn intake inadequacy was found in all age and sex groups. Cu intake inadequacy was most common in women older than 19 y. Fe, Zn, and Cu intakes over the upper limits were infrequent (Table IV).

Cereals and legumes were the main food groups contributing to Cu and Fe intakes. For Zn, the main contributors were cereals, legumes, and animal flesh (Table V).

DISCUSSION

In Chile, information about Fe, Cu, and Zn dietary intakes is scarce; the generally available studies use foreign food composi-

TABLE I.

IRON, ZINC, AND COPPER IN CHILEAN FOODS

Food group	*n*	Iron Mean ± SD (mg/100 g)	Iron CV (%)	Zinc Mean ± SD (mg/100 g)	Zinc CV (%)	Copper Mean ± SD (mg/100 g)	Copper CV (%)
Vegetables, leafy							
Beets green, raw	21	1.293 ± 0.641	49.6	0.558 ± 0.600	107.5	0.091 ± 0.044	47.9
Celery, raw	45	0.070 ± 0.038	54.7	0.066 ± 0.023	35.5	0.019 ± 0.007	37.2
Spinach, raw	22	0.070 ± 0.124	176.0	0.577 ± 0.191	33.2	0.158 ± 0.027	17.1
Lettuce, raw	36	0.534 ± 0.270	50.6	0.263 ± 0.250	95.0	0.065 ± 0.051	79.2
Vegetables, beans/peas							
Green peas, canned	26	0.954 ± 0.248	26.0	0.634 ± 0.195	30.8	0.260 ± 0.049	19.0
Lentils, dry mature seeds	21	6.573 ± 0.410	6.2	3.370 ± 0.353	10.5	0.792 ± 0.090	11.4
White beans, dry mature seeds	21	2.101 ± 0.294	14.0	0.978 ± 0.155	15.8	0.313 ± 0.170	54.3
Pinto beans, dry mature seeds	22	7.212 ± 1.930	26.8	2.489 ± 0.437	17.5	0.864 ± 0.152	17.5
Green beans, wet, raw	21	0.645 ± 0.103	16.0	0.286 ± 0.058	20.3	0.073 ± 0.019	25.5
Vegetables, root/tuber							
Onion, raw	22	0.186 ± 0.034	18.3	0.124 ± 0.067	54.4	0.039 ± 0.009	23.7
Potatoes, peeled, raw	11	0.245 ± 0.047	19.1	0.216 ± 0.078	36.0	0.110 ± 0.024	22.1
French-fried potatoes	23	0.756 ± 0.720	95.2	0.557 ± 0.149	26.7	0.194 ± 0.070	36.1
Carrots, raw	19	0.114 ± 0.043	37.9	0.078 ± 0.026	33.3	0.047 ± 0.013	26.6
Vegetables, other							
Mushrooms, raw	21	0.209 ± 0.097	46.4	0.413 ± 0.127	30.7	0.244 ± 0.092	37.6
White corn, raw	43	0.312 ± 0.056	17.9	0.355 ± 0.080	22.5	0.049 ± 0.015	30.4
Seaweed, dry (*cochayuyo*)	21	1.588 ± 0.385	24.2	0.585 ± 0.132	22.6	0.136 ± 0.073	53.2
Avocado, raw	28	0.478 ± 0.090	18.8	0.653 ± 0.174	26.6	0.325 ± 0.161	49.4
Green/red pepper, raw	21	0.277 ± 0.097	34.9	0.160 ± 0.027	16.6	0.023 ± 0.016	68.4
Tomato, red ripe, raw	21	0.183 ± 0.046	25.2	0.113 ± 0.026	23.0	0.037 ± 0.017	46.7
Summer squash, raw	12	0.310 ± 0.063	20.2	0.154 ± 0.088	57.1	0.079 ± 0.032	41.3
Fruits							
Peach with syrup canned	32	0.337 ± 0.346	102.5	0.056 ± 0.020	35.8	0.020 ± 0.029	149.5
Peach, peeled, raw	31	0.152 ± 0.035	22.9	0.083 ± 0.033	39.8	0.081 ± 0.026	32.0
Lemon, juice	25	0.011 ± 0.056	500.0	0.055 ± 0.019	34.0	0.006 ± 0.009	148.8
Apple, peeled, raw	24	0.159 ± 0.063	39.5	0.006 ± 0.009	159.2	0.025 ± 0.015	59.6
Melon, raw	21	0.186 ± 0.046	24.9	0.085 ± 0.029	34.4	0.010 ± 0.010	100.2
Orange, raw	27	0.056 ± 0.023	41.3	0.075 ± 0.017	22.1	0.051 ± 0.015	28.9
Raisins, peeled, raw	13	1.847 ± 0.744	40.3	0.140 ± 0.123	88.1	0.348 ± 0.110	31.5
Pear, peeled, raw	23	0.157 ± 0.060	38.3	0.061 ± 0.036	59.4	0.078 ± 0.034	44.3
Banana, raw	18	0.237 ± 0.067	28.3	0.094 ± 0.039	42.0	0.100 ± 0.016	16.1
Grapes, raw	25	0.088 ± 0.095	107.6	0.029 ± 0.022	76.2	0.046 ± 0.016	34.9
Grain products							
Rice, white, dry	39	0.590 ± 0.100	17.0	1.035 ± 0.153	14.8	0.095 ± 0.016	16.7
Cookies, sugar, commercially prepared	18	0.723 ± 0.288	39.9	0.543 ± 0.126	23.2	0.069 ± 0.040	58.5
Cookies, chocolate sandwich with cream filling	21	2.096 ± 0.711	33.9	0.399 ± 0.119	29.8	0.107 ± 0.065	60.4

tion tables, and these have been taken from non-representative samples. Despite the variability that this implies, in our study the contents of these minerals were comparable to those described in the US composition data. In this study we provide information of the Fe, Zn, and Cu compositions of 108 foodstuffs frequently consumed by the Chilean population, plus the content of native products that do not appear in any other table. This information allows a more accurate calculation of micronutrient intakes in this population. As a contribution to the dissemination of food composition, these data we will provide updated information to the Food and Agriculture Organization of the United Nations (FAO) and LATINFOODS Regional Food Composition Table (http://www.inta.cl/latinfoods or http://www.rlc.fao.org/bases/alimento/default.htm).

Fe intake was slightly lower than the reported values for developed countries in all age and sex groups, except in infants whose Fe intake was markedly low.[1,13–19] The fact that wheat flour in Chile has been fortified since 1952 with 30 mg of Fe/kg as ferrous sulfate and that bread consumption in our population is high except in infants may explain our findings. Zn intake was considerably low in all groups when compared with data obtained in industrialized countries,[1,4,13–18,20–23] whereas Cu intake was more comparable to values obtained in the United States and Europe.[1,4,13–18,20–22,24] Limitations of the dietary assessment methods may be partly responsible for the suboptimal trace element intakes estimated from self-reported food intake. However, because we measured trace element intake for only 4 nonconsecutive days, we cannot exclude the effect of daily variations

TABLE I.

CONTINUED

		Iron		Zinc		Copper	
Food group	*n*	Mean ± SD (mg/100 g)	CV (%)	Mean ± SD (mg/100 g)	CV (%)	Mean ± SD (mg/100 g)	CV (%)
Cracker, saltine, soda	21	0.617 ± 0.186	30.1	0.720 ± 0.162	22.6	0.194 ± 0.031	15.8
Flour wheat	37	1.160 ± 0.441	38.0	0.529 ± 0.183	34.7	0.212 ± 0.107	50.2
Bread, French	51	2.868 ± 0.890	31.0	1.256 ± 0.185	14.7	0.254 ± 0.042	16.3
Bread, white, commercially prepared	21	1.399 ± 0.203	14.5	0.570 ± 0.149	26.1	0.077 ± 0.033	42.2
Bread, whole wheat, commercially prepared	21	1.602 ± 0.358	22.3	0.897 ± 0.156	17.4	0.164 ± 0.046	27.8
Spaghetti, dried	19	3.092 ± 0.581	18.8	1.509 ± 0.142	9.4	0.263 ± 0.023	8.7
Nuts							
Almonds, dry	13	2.015 ± 0.799	39.6	2.438 ± 0.470	19.3	1.035 ± 0.278	26.9
Peanuts, dry	13	1.240 ± 0.141	11.4	2.887 ± 0.322	11.1	0.846 ± 0.182	21.5
Walnuts, dry	13	2.613 ± 0.434	16.6	2.982 ± 0.791	26.5	1.768 ± 0.584	33.0
Eggs							
Eggs (chicken), raw	32	2.207 ± 2.269	102.8	1.331 ± 1.367	102.7	0.737 ± 1.160	157.5
Dairy products							
Sweet condensed milk	22	0.419 ± 0.050	12.0	0.971 ± 0.078	8.0	0.059 ± 0.028	46.8
Milk, instant powdered	25	0.098 ± 0.150	152.5	2.482 ± 0.173	7.0	0.113 ± 0.071	63.0
Cow's milk fortified, powdered	17	7.226 ± 0.687	9.5	3.949 ± 0.891	22.6	0.413 ± 0.072	17.5
Milk, fluid	29	0.039 ± 0.021	55.2	0.356 ± 0.017	4.9	0.011 ± 0.004	34.8
Milk chocolate, fluid	15	0.252 ± 0.043	17.1	0.318 ± 0.041	12.9	0.060 ± 0.005	7.7
Cheese, pasteurized, aged (*chanco*)	25	0.012 ± 0.032	276.4	2.580 ± 0.300	11.6	0.007 ± 0.023	348.7
Cheese, pasteurized, fresh	19	0.101 ± 0.109	108.5	1.346 ± 0.210	15.6	0.018 ± 0.022	121.2
Cheese, gouda	29	0.051 ± 0.073	142.5	3.051 ± 0.372	12.2	0.014 ± 0.052	374.6
Yogurt, whole milk, flavored	24	0.067 ± 0.096	143.5	0.316 ± 0.072	22.9	0.000 ± 0.000	
Animal flesh, fish							
Tuna, canned	32	0.971 ± 0.237	24.4	0.431 ± 0.138	32.1	0.000 ± 0.000	
Sea eel, raw with skin	25	0.205 ± 0.097	47.2	0.344 ± 0.136	39.5	0.019 ± 0.007	38.1
Sea fish, *jurel*, canned	29	0.907 ± 0.761	83.9	0.417 ± 0.228	54.8	0.071 ± 0.064	89.4
Haddock, raw	25	0.151 ± 0.027	18.1	0.125 ± 0.016	12.8	0.034 ± 0.010	31.0
Animal flesh, shell fish							
Mollusks, clam, raw	25	1.522 ± 0.806	53.0	1.051 ± 0.202	19.2	0.138 ± 0.074	53.8
Shrimps, raw	25	0.314 ± 0.388	123.4	0.853 ± 0.157	18.5	0.444 ± 0.163	36.6
Mussels, raw	25	1.637 ± 0.665	40.6	1.996 ± 0.733	36.7	0.106 ± 0.045	42.6
Mollusks, *macha*, raw	25	3.114 ± 2.736	87.9	1.219 ± 0.308	25.3	0.168 ± 0.106	63.1
Oysters, raw	25	3.972 ± 2.450	61.7	1.298 ± 0.416	32.1	1.126 ± 0.386	34.3
Animal flesh, poultry							
Chicken, breast, raw	25	0.084 ± 0.074	87.5	0.543 ± 0.098	18.0	0.096 ± 0.029	30.5
Chicken, drum stick, raw	26	0.056 ± 0.065	115.9	0.879 ± 0.273	31.0	0.088 ± 0.021	23.4
Turkey, breast, raw	18	0.256 ± 0.133	52.0	0.857 ± 0.178	20.8	0.039 ± 0.040	103.5

in nutrient intake. Despite these considerations, this study provides an image of the Fe, Zn, and Cu intakes of the population of Santiago, which may be useful for other countries in Latin America that have similar patterns of food intake.

For all age and sex groups except infants, cereals and legumes were the most important food category accounting for Fe and Cu intake. Commercial foods for infants and vegetables were the main contributors to the Fe nutriture of infants, and legumes and cereals were the main food categories relevant to Cu intake. Animal flesh was the main contributor to Zn nutriture at all ages.

Drinking water may contribute to the total intake of some essential trace elements. The Cu exposure from drinking water in the same representative sample of the population of Santiago has been published recently.[10] The average daily Cu intakes provided by water, for the different age groups, were 0.025 in 0- to 12-mo-old individuals, 0.094 mg in 1- to 10-y-old individuals, 0.10 mg in 11- to 19-y-old individuals, 0.12 mg in 20- to 64-y-old individuals, and 0.09 in individuals 65 y and older. Thus, drinking water provides only a modest contribution to Cu intake in the population assessed.

According to the Institute of Medicine, the proportion of the population estimated to have a nutrient intake below the EAR may provide an approximation of the prevalence of nutrient inadequacy.[1] However, this information alone is not sufficient to determine when diets are inadequate because the balance of dietary inhibitors and enhancers of absorption influence Fe, Zn, and Cu bioavailabilities and, hence, determine absorption efficiency.[1,4] Further, humans can regulate absorption and/or excretion of the micromineral,[1,4] depending on its availability in the diet. For this reason, subjects with a low micro-mineral intake can adapt to a micronutrient intake below their requirements. Therefore, problems identified by dietary assessment need to be confirmed by clinical, biochemical, and functional studies, which were not included in the present protocol.

Fe inadequacy was particularly high in infants and women between the ages of 11 and 64 y. The prevalence of inadequacy

TABLE I.

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		Iron		Zinc		Copper	
Food group	*n*	Mean ± SD (mg/100 g)	CV (%)	Mean ± SD (mg/100 g)	CV (%)	Mean ± SD (mg/100 g)	CV (%)
Animal flesh, meat							
Beef, brisket, whole, boneless, raw	25	1.364 ± 0.344	25.2	3.898 ± 1.144	29.3	0.059 ± 0.045	76.3
Ground beef, raw	21	1.456 ± 0.277	19.0	3.063 ± 0.353	11.5	0.104 ± 0.037	35.4
Chop, beef, separable lean and fat, raw	11	0.445 ± 0.225	50.5	2.073 ± 0.365	17.6	0.248 ± 0.030	12.2
Chop, pork, separable lean and fat, raw	10	0.275 ± 0.158	57.3	0.863 ± 0.198	22.9	0.089 ± 0.009	10.2
Hamburger, raw	22	2.377 ± 0.267	11.2	2.856 ± 0.743	26.0	0.045 ± 0.055	122.1
Ham, raw	22	0.890 ± 0.246	27.6	1.231 ± 0.444	36.0	0.168 ± 0.098	58.3
Pork, loin, raw	25	0.579 ± 0.347	60.0	1.428 ± 0.538	37.7	0.092 ± 0.042	46.1
Pork sausage, raw	25	2.138 ± 0.855	40.0	1.609 ± 0.342	21.3	0.099 ± 0.057	57.7
Vienna sausage, raw	22	1.530 ± 0.226	14.8	1.452 ± 0.479	33.0	0.126 ± 0.034	26.6
Mortadella, raw	25	1.140 ± 0.268	23.5	1.507 ± 0.436	28.9	0.106 ± 0.039	36.3
Pate, bovine, commercially prepared	22	2.567 ± 0.913	35.6	2.015 ± 0.608	30.2	0.813 ± 0.977	120.3
Liver, bovine, raw	24	5.746 ± 3.957	68.9	3.962 ± 1.525	38.5	4.827 ± 2.868	59.4
Beef, shank cross cut, separable lean and fat, raw	25	1.558 ± 0.350	22.5	4.627 ± 1.005	21.7	0.101 ± 0.056	55.6
Beef, top round steak, raw	25	1.000 ± 0.498	49.8	3.685 ± 1.125	30.5	0.089 ± 0.037	41.6
Mixed, dishes							
Soup (chicken and rice), powder	26	0.421 ± 0.276	65.6	0.825 ± 0.159	19.3	0.070 ± 0.074	104.8
Dessert, dairy based							
Milk-based pudding with chocolate	9	0.564 ± 0.159	28.3	0.295 ± 0.089	30.3	0.247 ± 0.039	15.8
Milk-based pudding	30	0.387 ± 0.183	47.3	0.256 ± 0.071	27.8	0.088 ± 0.033	37.4
Ice cream, chocolate	26	0.459 ± 0.363	79.1	0.524 ± 0.163	31.1	0.220 ± 0.048	22.0
Ice cream, vanilla	22	0.000 ± 0.000		0.280 ± 0.111	39.7	0.094 ± 0.033	35.0
Sweet condensed milk, cooked	26	0.025 ± 0.056	223.9	0.834 ± 0.129	15.5	0.003 ± 0.018	509.9
Dessert, grain based							
Cake, commercially prepared	38	0.844 ± 0.385	45.6	0.353 ± 0.204	57.7	0.068 ± 0.061	89.4
Dessert, others							
Flavored gelatin, powder	28	0.000 ± 0.000		0.014 ± 0.050	367.2	0.034 ± 0.047	136.7
Sweeteners							
Sugar, granulated	21	0.172 ± 0.118	68.7	0.009 ± 0.028	315.9	0.000 ± 0.000	
Chocolate	20	3.969 ± 7.503	189.0	0.899 ± 1.728	192.3	0.512 ± 0.711	138.9
Sweet chocolate powder*	12	0.204 ± 0.218	106.9	1.686 ± 0.128	7.6	0.976 ± 0.057	5.8
Sweet chocolate powder*	12	0.812 ± 0.576	71.0	1.397 ± 0.102	7.3	0.464 ± 0.051	11.0
Marmalade	26	0.903 ± 0.153	17.0	0.478 ± 0.074	15.5	0.099 ± 0.030	30.0
Fats and dressings							
Vegetable oil	33	0.000 ± 0.000		0.000 ± 0.000		0.011 ± 0.020	179.7
Margarine	60	0.079 ± 0.097	123.0	0.000 ± 0.000		0.006 ± 0.018	303.8
Mayonnaise	31	0.013 ± 0.055	437.1	0.009 ± 0.027	311.2	0.003 ± 0.015	556.8

* Two brands of sweet chocolate powder analyzed.

CV, coefficient of variation; SD, standard deviation

was moderate in children and mild in adult and adolescent males. These results are consistent with findings of several studies performed in Chile, which demonstrated a high prevalence of Fe deficiency anemia only in infants and women at fertile age.[25,26] After we completed this study in 1999, the powdered milk provided free of cost to all infants by the National Complementary Feeding Program was fortified with 10 mg of Fe, 5 mg of Zn, 0.5 mg of Cu, and 70 mg of ascorbic acid per 100 g of powder. It will be interesting to assess the impact of these fortifications on Fe, Zn, and Cu nutrition status in the affected population.

A high prevalence of Zn inadequacy was observed in all age groups. Because there is no accepted sensitive indicator of Zn deficiency, the favorable response to Zn supplementation is used to measure the prevalence of Zn deficiency. Studies performed in Chile have shown a positive effect of Zn supplementation on growth velocity in infants, children, and adolescents.[27–29] The changes implemented by the National Complementary Feeding Program should allow a stricter evaluation of Zn deficiency in our population.

Cu inadequacy was of importance only in adult males between the ages of 20 and 64 y and females older than 19 y. Data from the literature have shown that biochemical or clinical Cu deficiency is prevalent only in infants recovering from malnutrition or children with chronic diarrhea.[30,31] More recent studies carried out by us have not demonstrated deficiency in an apparently healthy adult population by the traditional indicators of Cu status (serum Cu and ceruloplasmin protein or oxidase activity).[32,33]

Individuals with Fe, Zn, and Cu intakes over the upper limit seem to be infrequent; no subjects older than 10 y had such intakes, and low percentages of infants and children younger than 10 y presented high Fe and Cu intakes. However, 40% of infants had a Zn intake above the upper limit.

TABLE I.

CONTINUED

Food group	*n*	Iron Mean ± SD (mg/100 g)	Iron CV (%)	Zinc Mean ± SD (mg/100 g)	Zinc CV (%)	Copper Mean ± SD (mg/100 g)	Copper CV (%)
Beverages							
Softdrink, *Bilz*	25	0.088 ± 0.022	25.5	0.044 ± 0.014	32.7	0.000 ± 0.000	
Beer	28	0.075 ± 0.058	78.0	0.000 ± 0.000		0.008 ± 0.027	321.1
Mineral water	30	0.013 ± 0.033	254.3	0.027 ± 0.037	138.2	0.008 ± 0.012	143.4
Coca Cola	48	0.058 ± 0.056	97.3	0.057 ± 0.043	75.8	0.017 ± 0.023	134.4
Distilled grape liquor (*pisco*)	10	0.008 ± 0.010	129.1	0.012 ± 0.014	117.5	0.298 ± 0.165	55.2
Coffee, instant powder	19	2.619 ± 0.672	25.7	0.262 ± 0.110	42.0	0.016 ± 0.015	91.8
Flavored beverage, powder	34	0.000 ± 0.000		0.021 ± 0.039	183.6	0.003 ± 0.016	583.1
Tea, ground leaves, bag	27	5.444 ± 1.977	36.3	2.445 ± 0.602	24.6	1.969 ± 1.831	93.0
Wine, red	13	0.431 ± 0.065	15.0	0.037 ± 0.023	62.1	0.030 ± 0.013	42.7
Non-fat sauces							
Ketchup	29	0.778 ± 0.269	34.6	0.154 ± 0.080	51.9	0.188 ± 0.049	26.0
Tomato sauce	31	1.036 ± 0.303	29.2	0.188 ± 0.089	47.0	0.167 ± 0.040	24.1
Strained/junior cereals							
Cereals, oats, dry	14	2.662 ± 0.223	8.4	1.633 ± 0.199	12.2	0.342 ± 0.054	15.7
Breakfast cereal with chocolate	12	6.363 ± 1.246	19.6	13.539 ± 2.380	17.6	0.617 ± 0.080	13.0
Breakfast cereal	19	6.597 ± 1.125	17.0	11.452 ± 2.487	21.7	0.030 ± 0.037	123.3

CV, coefficient of variation; SD, standard deviation

From the nutritional standpoint, in the group reported here, cereals and legumes represented the main sources of calories and of Fe and Cu, in agreement with current (including Chilean) dietary recommendations; however, this finding should not lead to the conclusion that merely increasing consumption of these items will make nutritional deficiency of microminerals disappear, because legumes and cereals contain high levels of inhibitors of mineral absorption, so bioavailability is low. An alternative is to increase consumption of meats, in which bioavailability of minerals is high, but economic restrictions makes this possibility less feasible, and concerns about cardiovascular risk also restrict its use and favor lean meats. Current expert advice coincides in recommending fortifying staples in the diet to prevent deficiencies of Fe and Zn. Fortifications of milk, wheat flour, corn flour, weaning foods, and other foods have been used in different settings.

In summary, the results of this study suggest that the population in Santiago is at risk of Fe, Zn, and Cu deficiencies rather than overloads. All age and sex groups had a high risk of Zn deficiency, and the risk of Fe deficiency was found mainly in infants and women of fertile age. Adults of both sexes had a moderate increase in the risk of Cu deficiency. Data generated on the food content of

TABLE II.

DAILY IRON, ZINC, AND COPPER INTAKES IN THE DIFFERENT GROUPS BY AGE AND SEX*

Age	Sex	Energy (kcal/d)	Fe (mg/d)	Zn (mg/d)	Cu (mg/d)
0–12 mo	Males and females (*n* = 17)	834.4 ± 452.8	7.8 ± 9.6	3.8 ± 1.8	0.5 ± 0.3
1–10 y	Males and females (*n* = 43)	1391.2 ± 478.3	8.1 ± 5.3	6.2 ± 3.1	0.8 ± 0.5
11–19 y	Males (*n* = 23)	2409.0 ± 861.7	15.1 ± 7.3	8.9 ± 4.1	1.4 ± 0.7
P†		0.017	0.009	0.007	0.035
	Females (*n* = 16)	1597.0 ± 508.5	9.5 ± 4.3	5.7 ± 2.0	1.2 ± 0.3
20–64 y	Males (*n* = 55)	1877.3 ± 588.4	13.5 ± 6.5	7.6 ± 3.4	0.9 ± 0.4
P†		0.00001	0.00001	NS	0.014
	Females (*n* = 66)	1382.8 ± 442.0	9.1 ± 3.9	6.4 ± 3.5	1.0 ± 0.4
≥65 y	Males (*n* = 13)	1503.1 ± 488.0	11.4 ± 4.9	6.6 ± 2.9	1.1 ± 0.3
P†			NS	NS	NS
	Females (*n* = 19)	1467.0 ± 463.3	11.3 ± 5.0	6.9 ± 2.4	0.9 ± 0.4

* Mean nutrient intake per day was based on the average of 4 non-consecutive days. Data are presented as mean ± standard deviation.

† Student's *t* test for independent samples (male versus female).

Cu, copper; Fe, iron; NS, not significant; Zn, zinc

TABLE III.

IRON, ZINC, AND COPPER DENSITIES IN THE DIFFERENT GROUPS BY AGE AND SEX*

Age	Sex	Fe†	Zn†	Cu†
0–12 mo	Males and females ($n = 17$)	9.6 ± 8.0	6.1 ± 6.2	0.8 ± 0.6
1–10 y	Males and females ($n = 43$)	5.5 ± 2.4	4.5 ± 2.2	0.6 ± 0.2
11–19 y	Males ($n = 23$)	6.1 ± 1.6	3.7 ± 1.2	0.6 ± 0.2
P‡		NS	NS	NS
	Females ($n = 16$)	5.7 ± 1.5	3.6 ± 0.8	0.7 ± 0.1
20–64 y	Males ($n = 55$)	7.0 ± 2.0	4.1 ± 1.3	0.6 ± 0.1
P‡		NS	NS	=0.04
	Females ($n = 66$)	6.6 ± 2.4	4.6 ± 1.9	0.7 ± 0.3
≥65 y	Males ($n = 13$)	7.5 ± 1.7	4.4 ± 1.2	0.7 ± 0.2
P‡		NS	NS	NS
	Females ($n = 19$)	7.6 ± 1.6	4.9 ± 1.4	0.7 ± 0.3

* Mean nutrient intake per day was based on the average of 4 nonconsecutive days. Data are presented as mean ± standard deviation.

† Density was measured as milligrams per 1000 kcal per day.

‡ Student's *t* test for independent samples (male versus female).

Cu, copper; Fe, iron; NS, not significant; Zn, zinc

TABLE IV.

PERCENTAGE OF SUBJECTS BELOW THE EAR AND ABOVE THE UL IN THE DIFFERENT GROUPS BY AGE AND SEX

		Fe (%)		Zn (%)		Cu (%)	
Age	Sex	EAR	UL	EAR	UL	EAR	UL
7–12 mo	Males and females ($n = 13$)	76.9	5.9	30.8	41.2		
1–10 y	Males and females ($n = 43$)	14.0	0.0	18.6	11.6	2.3	7.0
11–19 y	Males ($n = 23$)	4.3	0.0	43.5	0.0	8.7	0.0
*P**		0.013		0.008		NS	
	Females ($n = 16$)	37.5	0.0	87.5	0.0	6.3	0.0
20–64 y	Males ($n = 55$)	10.9	0.0	80.0	0.0	16.4	0.0
P†		0.01		NS		0.05	
	Females ($n = 66$)	31.8	0.0	71.2	0.0	33.3	0.0
≥65 y	Males ($n = 13$)	7.7	0.0	84.6	0.0	7.7	0.0
*P**		NS		NS		NS	
	Females ($n = 19$)	0.0	0.0	57.9	0.0	21.1	0.0

* Male versus female, Fisher's exact test.

† Male versus female, chi-square test.

Cu, copper; EAR, estimated average requirement; Fe, iron; UL, upper limit; Zn, zinc

TABLE V.

CONTRIBUTION OF FOOD GROUPS TO IRON, ZINC, AND COPPER INTAKES IN ALL AGE GROUPS

Mineral	Food group	0–12 mo (%)	1–10 y (%)	11–19 y (%)	20–64 y (%)	≥65 y (%)
Iron	Fruits	1.6	2.5	1.8	2.5	3.3
	Vegetables	29.2	14.9	7.0	11.9	9.3
	Cereals and legumes	21.2	57.1	69.5	58.7	67.1
	Milk and dairy products	0.9	4.2	2.0	1.2	1.4
	Eggs	0.3	1.6	2.8	2.2	0.9
	Animal flesh	7.0	8.8	9.5	13.1	11.1
	Fish and sea foods	0.0	1.2	1.5	1.9	1.1
	Oils and fats	0.0	0.1	0.3	0.1	0.1
	Other	39.8	9.6	6.3	8.3	5.8
Zinc	Fruits	0.6	1.3	1.3	1.5	1.3
	Vegetables	12.0	11.4	4.6	6.8	7.2
	Cereals and legumes	17.5	29.9	41.5	32.5	35.6
	Milk and dairy products	35.1	20.6	14.9	9.3	12.2
	Eggs	0.3	1.4	2.9	2.1	0.9
	Animal flesh	30.2	31.1	30.3	43.9	38.6
	Fish and sea foods	0.0	1.3	1.8	1.0	1.3
	Oils and fats	0.1	0.2	0.5	0.3	0.2
	Other	4.2	2.9	3.2	2.6	2.7
Copper	Fruits	6.8	7.1	6.3	6.4	7.4
	Vegetables	32.7	17.4	10.1	13.3	13.2
	Cereals and legumes	31.6	42.0	47.4	42.4	47.6
	Milk and dairy products	14.5	8.0	5.7	2.4	3.0
	Eggs	1.4	5.4	10.0	8.3	3.4
	Animal flesh	7.8	11.5	9.3	16.8	15.1
	Fish and sea foods	0.0	0.7	1.5	0.9	0.7
	Oils and fats	0.1	0.2	0.3	0.2	0.3
	Other	5.0	7.7	10.1	9.2	9.3

Fe, Zn, and Cu will help to assess the nutrition status of these micronutrients.

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